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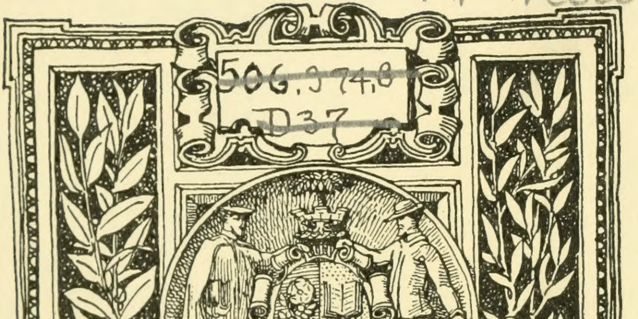

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Delaware County Institute of Science

Carolus M. Broomall, Editor.

PUBLICATION COMMITTEE:
T. Chalkley Palmer, Chairman; Henry L. Broomall,
Trimble Pratt, M. D., Charles Potts,
B. M. Underhill, V. M. D.

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Delaware County Institute of Science

VOL. IV, NO. 1 OCTOBER, 1908

A HALF HOUR'S TALK ON MINERALOGY.*

BY JOSEPH WILLCOX.

The invitation of your club to give a lecture on the subject of minerals was accepted with some hesitation, as I now find myself in the new rôle of a professor for the purpose of making an attempt to extract from dry stones and massive rocks instructive entertainment for an expectant assemblage of cultured listeners.

At the same time I have been confronted with the embarrassing fact that, in the hurried preparation of this paper, no books of reference could be consulted, and only a treacherous memory could be relied upon for the accuracy of many of the statements included in it. In the following paper the use of technical words has been avoided as much as practicable.

Mineralogy is the science which treats of the substances of which the rocks and soils of the earth are composed. It may be proper to state here that all the soil of the earth is merely disintegrated rock broken down by the ravages of the air and water, in addition to the action of frost, during a vast period of time.

Although the study of mineralogy is one of the most attractive of all the scientific pursuits, the discussion of the subject cannot be made a matter of great interest without the

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* Paper read before the Twilight Park Nature Club, Twilight Park, Catskill Mountains, July 23rd, 1908.

exhibition of specimens illustrating the character of the different species.

As no specimens of minerals are available for exhibition, at the present time, except a few of those which are utilized for ornamental purposes, the time this morning will be partly occupied in discussing the composition and other characteristics of such minerals.

It may be pertinent to state now that, in the opinion of the present writer, it would be desirable to include, as a part of the education of young ladies the study of mineralogy, at least to a limited extent, in order that they may appreciate more fully the composition and other characteristics of the many minerals used for ornamental purposes, including the knowledge of the rocks in which they occur, and the different localities where they are found.

The following comprises the list of specimens that your president has been able to supply to me as aids in illustrating some of the minerals referred to in this paper, and which are now on the table before you : —

A quartz pebble from the conglomerate rock in this vicinity, a brickbat fragment not native to this vicinity, a specimen of obsidian (an eruptive rock) from the Yellowstone National Park and a piece of geyserite from the same place, two specimens of granite and a green apple.

The old Devonian rocks around us here are barren in mineral specimens, and the soils in this vicinity consist merely of the glacial sweepings from the country further north of us.

Although the number of known minerals exceeds one thousand, probably more than nine-tenths of the bulk of the earth's solid crust consists of less than a dozen species of them, which may be enumerated as quartz, and the several varieties of feldspar, mica and hornblende.

In dealing with the subject under consideration, it is proposed to commence with the most simple forms, termed elements.

It is a custom to mention the word element as representing the most simple form in which it was created, although future investigations may determine some of them to be compound substances.

Although the known elements somewhat exceed fifty in number, the minerals above enumerated are almost wholly composed of the following: — Silicon, aluminum, oxygen, calcium, sodium, potassium, carbon and iron. In addition to these may be mentioned hydrogen, as one of the two components of water, and nitrogen, as one of the components of the atmosphere, and chlorine, which when combined with sodium forms the salt ot the sea.

It is proposed to refer to these elements first in their original form; then, secondly, in combination with oxygen, and thirdly in their combination to form the minerals above mentioned and including some specially used for ornamental purposes, as the time at our disposal this morning will not permit the discussion of much other matter connected with the subject of mineralogy.

Silicon, the most abundant of all the elements, is with difficulty separated from any of its combinations, and it is rarely seen. When combined with oxygen it forms the mineral quartz. Quartz is a hard mineral and ranks as the fourth in the scale of hardness. It often occurs in transparent crystals, as clear as glass, with six sides and terminated with pyramids with six sides. Glass is made with quartz and soda, and the sands of the sea consist almost wholly of quartz. It is one of the three minerals used in the manufacture of porcelain ware. Agate, chalcedony, carnelian, onyx and sardonyx are some of the varieties of quartz. When colored yellow, quartz is called citron stone, which is sometimes sold as topaz, and when dark colored it forms smoky quartz or cairngorm. When the transparent variety is polished it is sold as a rhinestone. When purple it is amethyst. When chemically combined with a little water it forms the mineral opal.

The specimen of geyserite on the table was deposited from the hot waters from the geysers in the Yellowstone Park. It is composed of silica combined with a little water, and it is nearly similar in composition to the mineral opal.

A variety of quartz when green is called chrysophrase. The dark colored flint stone, found abundantly in the chalk beds of England and formerly used on the old fashioned gun locks, consists of quartz. All the rock formations of the earth, including the soils, consist largely of silica, both in the free state as quartz and in combination with other substances, chiefly alumina.

Aluminum, the second most abundant of the elements, has lately assumed a prominence in the industrial arts. It is the lightest in weight, as well as the most abundant of all the metals.

It is only successfully reduced from any of its combinations by means of the intense electrical heat. The most extensive works for the reduction of aluminum in America are located at Niagara Falls. Aluminum is always found in its natural state to be combined with oxygen, and in that condition it is called alumina, which in its free state is a rare mineral, not found at many localities. Corundum is the only mineral consisting wholly of alumina. It is next to the diamond in hardness, and in its crude form it is used only as an abrasive material, superseding emery, which is an impure corundum, consisting partly of iron. At two known localities, viz: in India and in the island of Ceylon, corundum is found in a condition suitable as gems. Some translucent, six sided or hexagonal crystals, when polished, show six opalescent lines radiating from a central point. This variety is used as an ornamental stone and is named the asteriated sapphire. When transparent, corundum is called colorless sapphire. When blue, it is sapphire merely. When yellow it is called Oriental topaz, and it then excels the true topaz in brilliancy. The red corundum is the queen of gems, the ruby, the most beautiful of all minerals, and, when of deep color, is more valuable than a diamond of the same size.

We thus find that alumina, one of the most abundant substances on the earth, is, in one of its forms, the most beautiful and valuable of all the minerals. When combined with phosphoric acid and water, alumina forms the mineral turquoise, formerly found in Persia only, but now produced more abundantly from the mines in New Mexico.

Nearly all of the alumina on the earth is combined with silica, and the resulting compound is called the silicate of alumina. The chief portion of the earth's crust consists of the silicate of alumina, combined with other substances, thus forming a great variety of mineral species.

The white clay used as one of the components of porcelain ware is a silicate of alumina. It is named kaolin. Common clay is the same, though colored red by a little of the oxide of iron. The rock slates of the earth were originally deposited under water as clay beds.

Oxygen, one of the three most abundant of the elements, is an invisible gas. It is in evidence everywhere. The waters of the oceans, and also the atmosphere, are chiefly composed of it. With the exceptions of chlorine and flourine, it is practically found to be combined with all the other elements. The ores of many of the metals, including the second most abundant, iron, are merely combinations of such metals with oxygen. Though invisible alone, it usually causes great changes in the character of the other elements when combined with it, notably with the lightest of the gases, hydrogen, in forming water. When combined with iron it forms a red rust; with copper it makes green verdigris; with mercury, the red oxide. Hematite and magnetite consist of iron and oxygen. The great changes made by its combination with the metal aluminum have already been referred to, and also with silicon.

Calcium is the element which, when combined with oxygen, forms lime. The latter, an alkaline earth, is never found in an uncombined state. Its most abundant combination is with carbonic acid, resulting in the well known mineral, limestone. When magnesia is included, the mineral dolomite is produced, which in many cases forms mountains. A large portion of the surface of the earth is covered with beds of limestone rocks. Nearly all running waters contain carbonate of lime in solution, and vast quantities of the latter are carried daily into the sea. Much of this is, in turn, reconverted into solid matter by the action of corals and shellfish. The pearl consists of carbonate of lime. Limestone performs a most important function as a flux in the smelting of iron and other ores, and in making mortar and cement.

The stalactites and stalagmites found in caves are formed from waters containing carbonate of lime in solution. Rain water, when slowly percolating through the fissures in the limestone overlying caves, dissolves a small amount of the rock. When it reaches the roof of the cave some of the water is evaporated and the limestone that it contained is deposited there. This process, when long continued, forms stalactites. If the water flows slowly and all of it is dried on the ceiling, only stalactites will be formed. But if some of such water should fall to the floor a stalagmite will be formed there and piled up slowly by the same process. In some cases stalactites will continue to be formed downward and stalagmites to grow upward until they reach each other and become united. The pillars in caves are thus formed.

The elements sodium and potassium have such an affinity for oxygen that when in contact with water they immediately decompose it and combine with the oxygen furiously, with the accompaniment of a great amount of heat. The combination of sodium with oxygen forms soda, and potassium combined with oxygen forms potash. Soda is abundantly found as a component of many mineral species. United with chlorine it forms the salt of the oceans and of the salt lakes. During the slow decomposition of the rocks of the earth many of the substances composing the minerals are made soluble and are leached out and carried, in solution, to the salt lakes and into the oceans.

The waters in the oceans are considered to have been originally fresh, and subsequently made saline by the salts carried into them daily by the fresh water streams. All lakes without an outlet, including the Caspian Sea, have become salty by this means. Soda, being one of the alkalies, has the faculty of combining, under great heat, with silica and some other refractory substances and causing their fusion. Thus a mixture of powdered silica or quartz, with soda, when subjected to great heat, forms glass. Soda is also employed, when combined with fat, in the manufacture of soap.

Potash is also one of the components of the most common minerals and also of plants. It is, therefore, one of the most important substances included in artificial fertilizers.

Carbon is one of the few elements that are found in the free state. The mineral graphite, or plumbago, consists of carbon combined with a small quantity of iron, about one or two per cent. In its purest condition carbon forms the mineral diamond, the hardest of all known substances; while graphite, consisting almost exclusively of carbon, is one of the softest of minerals. In the same category it may be brought to mind that while mineral coal and charcoal are common articles for fuel, graphite, practically of the same composition, is both incombustible and infusible. These are two of the anomalous cases often encountered in scientific pursuits, where the same substances, under varied conditions, manifest great diversity in character.

Combined with oxygen, carbon forms carbonic acid gas. All limestones, including marbles, and all corals, shells and chalk, consist of lime combined with carbonic acid. When combined with sulphuric acid, lime forms the mineral gypsum, which in its purest condition is transparent, and it often occurs in beautiful crystals called selenite. Alabaster is a variety of gypsum.

Next to aluminum iron is the most abundant of the metals. It is one of the most common of the constituents of the minerals occurring everywhere.

With one exception the ores of iron consist of that metal combined with oxygen in greater or less proportion under the names of magnetite and hematite. The exception noted above applies to the ore which is composed of iron combined with carbonic acid, and known as siderite.

A small portion of carbon, when combined with iron, effects a remarkable change in its character; in fact, the latter is converted into steel; and the hardness of steel, of the several grades, is chiefly due to the amount of carbon combined with it. There are several metals which, when combined with steel, make the latter harder and tougher, especially the metal nickel. Some of the modern armor plates for battle ships are made of this combination. Some of the oxides of iron are so deeply colored red that they are used as paint. And some of the minerals containing iron are colored in proportion to the amount of iron in them.

Sulphur, one of the useful elements, is not found in the free state in many places. The most important locality for sulphur is on the island of Sicily, where it often occurs in beautiful and brilliant yellow crystals. Sulphur combines easily with oxygen, burning with fire and resulting in sulphurous or sulphuric acid gas, of which vitriol is made. Sulphur is sublimated or converted into vapor at a low degree of heat. It performs an important function in nature in arresting many of the metallic substances when dissolved in water and combining with them; otherwise they would be carried to the sea and lost. Many mineral beds and veins owe their existence to this process.

The ores of many of the metals consist of such metals combined with sulphur, including the following as some of them, viz: Silver, copper, zinc, tin, arsenic, mercury, antimony and many others. Sulphur is found sometimes in large deposits combined with iron, forming iron pyrites. Iron pyrites is a mineral often occurring in beautiful cubical crystals, and in many modifications of the cubical system. In color it resembles gold. It is the ore in which the gold in Colorado is chiefly found. Sulphur is one of the necessary components of animals and plants. It is found quite abundantly in hair, feathers and eggs particularly.

Magnesium is a metallic element, and it somewhat resembles in appearance the metal aluminum. It combines rapidly with oxygen, and when burning it is highly luminous. The light from burning magnesium is used by photographers when making photographic negatives at night. When combined with oxygen, it forms magnesia. Combined with sulphuric acid, it forms Epsom salts. In combination with silica and a little iron, it forms the mineral chrysolite, which sometimes exists in great beds of rocks, especially abundant among the mountains of North Carolina.

Chrysolite in its purest condition forms the beautiful mineral, olivine, much admired as an ornamental stone. When combined with water (ten or twelve per cent.) it forms the green mineral, serpentine, sometimes called serpentine marble. The most beautiful specimens of this so-called marble are found near Easton, in Pennsylvania, and in Harford County, in Maryland. Serpentine is sometimes found included in limestone. This variety is called verde antique marble. Talc and soapstone are varieties of serpentine. The former is found abundantly in St. Lawrence County, in New York, in Cherokee County, in North Carolina, and in an adjoining county in Georgia. When powdered, it is used in adulterating paper, and also as a toilet powder, sometimes called talcum.

So much time has already been consumed in describing a few of the substances which enter into the composition of some minerals, that there is now only an opportunity for a brief reference to some of the most common and important of these minerals.

Feldspar is one of the most abundant, as well as one of the most important of minerals. The most common, called orthoclase, consists of silica, alumina and potash. When decomposed, it forms the chief portion of the clays of the earth. It supplies two of the substances used in the manufacture of porcelain ware, which consists of quartz, feldspar and the white clay, kaolin. Orthoclase feldspar, when decomposed, affords the chief supply of potash for the use of plants.

There are many varieties of feldspar. The soda feldspar is called albite, and the chief portion of the soda on earth and in the seas has been derived from the decomposition of albite.

The moonstone, found in Ceylon, is a variety of feldspar.

The green amazon stone found near Pike's Peak, in Colorado, is a variety of feldspar. A transparent variety, consisting of a few specimens only, has been found in a mica mine in Mitchell County, North Carolina. A variety called Labradorite is found in Labrador. It is highly opalescent, like moonstone, but it reflects several beautiful colors.

Hornblende is an abundant mineral, composed of silica, alumina, lime, magnesia and iron. There are many varieties, differing somewhat in composition. The purest form of it is in diopside, found in Jefferson County, New York.

Mica, or isinglass, is a mineral not differing much in composition from feldspar. It is used chiefly in the doors of stoves. Like feldspar, it forms a fertile soil when decomposed.

Granite is composed of feldspar, quartz and mica. In some granites the mica is replaced with hornblende. This variety is termed syenite.

The red color in some granites is due to an excess of iron in the feldspar, especially in the granite from Nova Scotia.

A few of the substances composing the common minerals serve as an important and even a vital factor in the animal and vegetable economy in promoting the growth of all the vegetable kingdom; and inasmuch as no animal life can subsist without vegetable life, all created living beings are dependent on a few mineral substances for their existence on the earth.

The elements or substances necessary for plant growth are oxygen, carbon, hydrogen, nitrogen, lime, potash, iron, phosphorus, soda and sulphur, with small proportions of several others.

The four first mentioned are found in the air, and all the others exist in the soil, having been decomposed and released from the minerals and made available for assimilation by plants by the slow processes of Nature.

Each blade of grass, and each grain of corn, and also the fruits contain every substance necessary for the growth of animal life.

The proudest living man has nothing in the composition of his body that may not be found in that green apple on the table before me.

It is reasonable to presume that the primary purpose of God in forming the earth was to prepare a habitable place for his crowning work, the noblest of all created beings, man. The human species, *Homo sapiens*, is the latest known addition to the so-called fauna on the earth. It will be admitted that the faculty or endowment expressed by the specific word *sapiens* has not been maturely developed in all the individuals of the race.

A FAMILIAR TALK ON DELAWARE COUNTY FROGS.*

BY T. CHALKLEY PALMER.

The youthful beginner in Natural History, who is desirous of grasping at once the concept of *genus* could not do better than make a little study of our frogs. The number of species is not large and the genera are very few indeed, yet individuals abound ; so that, while material for study is in quantity, there is not likely to be the mental confusion that would follow an attempt of the unbooked to observe and record the members of some intricate family like the minnows, or even the less difficult, yet still puzzling natural group like the snakes.

The study should be made, of course, upon the concrete things — the frogs themselves. Books should come into action only after considerable collection of specimens, considerable observation of the living creatures at large or in captivity. Names and classifications are of little value, either first or last, except as they lend precision to observations made and lead to new knowledge. In youth especially the one great thing is to learn to see with the eye, to understand for one's self the facts observed, without too much reference to things in printed books. Boys are naturally observers, and many a boy knows facts about frogs and their ways that have never been printed. Meantime the busy people that compose the scientific world are very desirous of knowing all about the habits of living things, many of which they know only by name and technical description — knowledge of the sort, precisely, that can be and is collected, in however haphazard fashion, by young people in their fishing excursions, their picnickings, their flower hunting trips in Spring.

Our native frogs, strictly so called, of the genus *Rana*, fall into five quite distinct species. Beside these there are the tree frogs of three species, and in closely related genera two more

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* Abstract of informal remarks before the Institute.

— the cricket frog and the swamp tree frog. At the most, then, we have ten kinds of frogs and tree frogs. It is not a large list, and one might, with good fortune, succeed in meeting members of all the species in a single year. However, two or three of them are rare, or at least seldom seen.

Perhaps every one knows, by this time, that all frogs, as well as the toads and other batrachians, begin life as tadpoles, or pollywogs. The eggs are laid in slow-flowing streams, in ponds, in pools, ditches or swamps. They are in the form of blackish, shot-like specks, enclosed in masses of clear jelly. This jelly is of nearly the same specific gravity as water. Sometimes the masses float about in the water, sometimes they rest upon the bottom. The heat of the sun seems to have some sort of action on certain kinds of frog spawn, causing it to become lighter, much after the manner of various algæ, which, as the sunlight strikes them, generate gases that bring them to the surface. In the case of the algæ the gas is largely oxygen, which is generated by the sunlight in the living cells furnished with the green substance called chlorophyll. In the spawn the bubbles are in all probability carbon dioxide ("carbonic acid"), the gas that is such a constant product of vital activity in animal life.

The eggs are at first approximately globular. They soon become indented on one side and each gradually uncurls a flat tail. The "head" — which is in reality the body — begins to shape itself, the tail continues to grow, the tadpole, in short, to assume its proper form. After due preparation the tadpole eats its way out of the surrounding jelly and swims freely about. The jelly itself finally disappears. What becomes of it? Sometimes it liquefies to a large extent, but other times it may possibly be eaten by the tadpoles, in whole or in part. However this may be in the case of frogs, I have found that the jelly about the eggs of the water newt, when kept in a cup of water until the tadpoles appeared, and thereafter, was quickly and completely devoured by those tadpoles, which meantime grew with amazing rapidity, and this in the absence of other visible food. *

The tadpoles so brought forth are essentially fish-like in habit. They have small, round mouths and external gills. They are without proper lungs. Their bodies are soft, and they are the helpless prey of a variety of water dwellers. The crayfish especially — that small but fierce member of the pugnacious race of crabs and lobsters — destroys many of them, and eats a few. Destruction seems to be the main object. Let me relate a little circumstance in illustration.

I had been wading up a little meadow stream one evening, collecting with a hand net a quantity of minnows for next day's bass fishing. From among the minty growths dipping into the water on either bank there came up, and into the bucket, numbers of large tadpoles and a few crayfish. These all were in along with the minnows, and the bucket stood out until next morning. Then a horrible sight awaited me. The crayfish, not more than eight or ten in all, had worked havoc. All the tadpoles and half the minnows were dead of brutal stabs. The ruffians had killed, as it were for mere love of killing, over one hundred defenseless fellow prisoners. Not satisfied with this, they had turned upon each other, and only two crayfish retained all their legs and pincers.

Cast amid such wretches as these, the tadpoles must have a sorry time of it. But other enemies abound. The water snake, cunning and agile, engulfs them in large numbers. Various fishes eat their share. Of millions that hatch, only hundreds get themselves legs at last, so harried are they night and day. And with the legs comes little succor from trouble. Wading birds, with long necks and dagger-like beaks, stab the frogs upon the bottom of the pool, and serpents with yellow stripes waylay them in the grass upon the bank. On all sides, and forever, destruction waits and threatens.

The tadpole is apparently constructed for a vegetable diet.

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* Observation on the spawn of water newt, 1905.

It is believed to subsist principally upon green algæ, such as that called "frog spittle" and upon the microscopic overgrowths of the same, like infusorians and diatoms. But it will take meat at times. Last summer I observed in a pool near home the body of a large frog. This frog was but too evidently dead, yet it seemed to move in a spasmodic manner. When it was stirred up with a stick a dark brown stream of panic stricken tadpoles came out of its gaping mouth. They had been gorging themselves upon the body of the departed. Now this was a wide departure from vegetarianism, and amounted to practical cannibalism.

The identification of the different species when in the tadpole state is possibly within the power of an expert, but it can scarcely seem easy to any one, and certainly not to an amateur whose observations are only casual. The tadpoles of the common toad, however, are easily distinguishable. The transformation into the frog would seem to take place, as a rule, before the end of the first summer. But certainly this is not always the case. Very large tadpoles, possibly those of the bull frog or the large green frog, may be seen huddled together in the depths of a frozen pond in mid-winter. The transformation, once begun, goes on rapidly, and a legless, gill-breathing creature becomes a thing of legs and lungs within three weeks from the first budding of the hinder limbs. It would seem a wondrous change for such a space of time. The tail is gone, the feet have all their exquisite little toes, the small, round mouth has expanded into the generous, ear-to-ear affair we know so well. The creature has now a voice, and knows how to use it. He is altogether another being.

Our frogs, how numerous soever in individuals, seem all to belong to the following species:[*]

Rana catesbiana,	Shaw.	Bull Frog
" *clamata*,	Daudin.	Green Frog

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[*] For technical descriptions of the species, the learner is referred to David Starr Jordan's excellent "Manual of the Vertebrates."

Rana virescens, Kalm. Leopard Frog
" *palustris*, Le Conte. Pickerel Frog
" *sylvatica*, Le Conte. Wood Frog
Hyla versicolor, Le Conte. Tree Toad
" *pickeringii*, Holbrook. Pickering's Frog
" *andersonii*, Baird. Anderson's Frog
Chorophilus triseriatus. Swamp Tree Frog
Acris crepitans, Baird. Cricket Frog

THE BULL FROG, (*Rana catesbiana*, Shaw).

"The largest of the frogs; in ponds and sluggish rivers, from Kansas east; remarkable for its sonorous bass notes." So Jordan ends a technical description of this species.

This frog is easily distinguishable from all others as follows: — It is more or less green above, with few spots or none on the back, and without the two folds parallel to the spine, which are so conspicuous in all the other common frogs. Without further description we turn our attention upon a specimen. This individual was an inhabitant of a pond near Ridley Park. It is nearly as large as any frog one is likely to meet in this vicinity, and its feet are comparable in size to those of a young duck. In the same pond were seen six others, all equally large, and probably all of the same hatching. This family of batrachians habitually sat around the edges of the water, at nearly regular intervals, submerged to the throat. Of an evening one saw of them only a few yellowish spots — the throats, in fact, which showed in the twilight in marked contrast with the dark, smooth surface of the water. The booming at night was something to remark. The tumult went on all the evening; it was still going at midnight, and it died away only in the gray of the morning. This pond was of no great depth or extent, and many attempts were made to capture one of the frogs alive. But this was found to be a difficult matter. When approached, no matter with what precautions, all disappeared effectually. There was something a trifle mysterious about this vanishing.

They seemed not to swim off into the middle of the pond. They appeared rather to sink out of sight at the places where they had been sitting. I finally found that each frog had a retreat of his own — a narrow, horizontal gallery running back beneath an overhanging bank ; a burrow, in fact, after the pattern of a muskrat den. One of these holes was found to be more than three feet deep — how much more I could not discover. These evidently were old residents, and each had built his house.

The above observation about the bull frog's habits I had supposed to be new. But within two months after it was made I read, in Mary E. Bradford's curious little book, "Up and Down the Brooks," an account of a small California lad who volunteered to the lady the information "that frogs have regular sleeping places in holes on the sides of pools." "You can come to this pool at night and see them," said he ; "some go into the grass, and the same frogs go in the same holes."

This bull frog died of a blow on the head. His stomach, on investigation, showed a number of caterpillars, three or four grasshoppers and a field mouse.

The liking of frogs for mice has been commercialized by a frog farmer in New England, who regularly feeds his drove, or flock — what shall we say ? —with field mice. He sits in a chair and holds the mice by the tails, while the frogs come gravely up and swallow them.

THE GREEN FROG, (*Rana clamata*, Daudin).

This is next to the bull frog in size. It gets to be three inches long. It is brownish green on the back, bright green about the head. On the back there are little, black specks. I have only young specimens to show.

It is a common frog along meadow rills and in ponds. I do not think it is in the practice of burrowing in the bank like the bull frog. It generally swims away to the deepest part of the pond when disturbed. It is capable of making a noise of some loudness.

The Leopard Frog, (*Rana virescens*, Kalm).

Of this frog Jordan says: "Green, usually bright." That may be so. Some small specimens from the marshy shores of the Delaware, at Chester, were of a bright green, others from the same place rather brownish or bronzy. But in the quite adult condition, as I found them at Augustine Pier, Delaware, and as they are here exhibited, they can hardly be called green at all. These Augustine Pier frogs are perhaps rather remarkable for size also. The limit of length, 2¾ inches, scarcely covers some of the specimens.

Let us recall the California small boy. He spoke of some frogs that "went into the grass." Now this is what the leopard frogs did at Augustine Pier. Instead of jumping into the pond and swimming for the deepest water, as did the green frogs, they one and all turned and sprang up the bank into tall grass, and with incredible jumps disappeared in the most tangled parts of the herbage. Some went into a little thicket of black berries, where it was impossible to follow them. Three or four, however, were captured. Residents called them "spring frogs," not because they live in springs, but because they are such magnificent jumpers; and they informed me that these same frogs are to be found, near at hand, six inches long, or twice as big as those I had — which is, of course, a statement of a very doubtful character.

I note here, that the smaller frogs of this same species, on the marshy shores of the Delaware at Chester, have the same habit of jumping away from the water when alarmed, and that they are capable of most remarkable leaps.

The Pickerel Frog, (*Rana palustris*, Le Conte).

This is the most familiar of all the genus, at least to the dairy farmer and his family. It delights to live in the spring house, and is given to jumping into pans of milk. It is a beautiful creature. The alcoholic specimens entirely fail to show the fine colors wherewith it is decorated in life, and still less do they convey any notion of the bright, golden beauty of the eyes.

I have kept this frog in captivity for weeks at a time. It becomes reconciled to its cage after a while. Only one must be careful to keep it supplied with water. Two hot summer hours in a perfectly dry box will not only kill it, but shrivel its body remarkably.

My note book says: "When this frog croaks, * * a large pouch swells out on each side of the lower jaw." These pouches, I now add, are composed of light blue membranes. Many a time, when sitting at my desk reading or writing, my lamp before me, I have heard my frog begin his evening song. There he sat in his cup of water, gazing fixedly at the light, his pouches expanded, contentedly piping away.

THE WOOD FROG, (*Rana sylvatica*, Le Conte).

This is one of the more rarely seen frogs. The specimen here presented is from Bridgeport, New Jersey. I have seen but three of these, all of them in woodland pools. Jordan says: "Common in damp woods; an almost voiceless frog." I know little of it. It is noticeable for its coppery red, iridescent back, and for a large, jet black, oblong blotch about each eye.

THE COMMON TREE TOAD, (*Hyla versicolor*, Le Conte).

Most of the small boys know this remarkable creature. A frog that can both climb a pane of glass and make himself into the likeness of a bit of "moss" on a tree trunk, is apt to attract attention. It is sluggish in its movements, and will perch upon the hand, or crawl over one's clothing, with an air of touching confidence. It is easily tamed, and will take flies and bugs from its entertainer in a most matter-of-fact way. Its body is always moist to the touch, and people with uneducated nerves call it clammy, and corpse-like.

The changes of color of which it is capable were noticed long ago, and found mention in the scientific name, *versicolor*. My notes say of our specimen: "I kept it four days. The color changed several times from a brownish to a gray, with tinge of green, and back again. At night the color was generally brown. The change was sometimes effected in less than a minute. A broad, brownish band on back, which showed when the general color was between the two extremes, and became invisible at other times."

The toes of this frog are provided with suckers, which enable him to do his tree climbing. Everybody must be familiar with his cheerful song. This song is popularly supposed to indicate an approaching storm. It probably indicates nothing beyond the fact that the frog is feeling reasonably contented, or even gay.

PICKERING'S TREE FROG, (*Hyla pickeringii*, Holbrook).

A most dainty little creature, one inch long at most. The only specimens I have seen, which I came upon at Chester Heights one day in June, were of a creamy white, each with a faint brown oblique cross upon its back. They were among the roots of some damp grass, not on trees.

THE GREEN TREE FROG, (*Hyla andersonii*, Baird).

Jordan says of this: "Deep pea green; sides with irregular yellow spots; a green spot on throat; a purplish band from eye to arm. * * 1½ inches. N. J. to S. C.; rare."

This is a description calling for a very vivid sort of frog. It is such. Two specimens were found in a damp gravel pit some years ago, and they were most beautiful. They lived in my study for a week or more, finally disappearing, up the ventilator, as I suppose. They seemed, like the ordinary tree frog, quite at home wherever they happened to find themselves. They crawled about the desks and door frames, or over one's clothes, in a manner devoid of all appearance of excitement.

THE SWAMP TREE FROG, (*Chorophilus triseriatus*, Wied).

A little frog with which I am unacquainted, but said to be native here. It is described as being of a "bluish ash" color, about one inch long, and to be found mostly in swamps, not in trees. Cope says of its cry: "A rattle, with a rising inflection at the end," and Jordan adds, "or like the scraping of a coarse-toothed comb."

THE CRICKET FROG, (*Acris gryllus*, Le Conte).

One of the most common, yet one of the shyest. It is the little, sly, mysterious creature that peeps shrilly all about one's feet during the evening walk in Spring. A hundred peeps come out of the wet grass and swampy pools, ear-piercing in nearness. But not a frog is in sight. It is not at such a time that one need hope to see the cricket frog. The time to find him is at noontide, when he goes out with ten or fifteen of his brothers to sun himself on a sandy bar beside the meadow rill. As you approach, these frogs, having some confidence that they will be overlooked on account of their inconspicuous colors, crouch quietly down upon the sand. But fear finally overcomes them, and they reveal themselves in their efforts to reach the water.

The most obvious distinctive marking upon these frogs is in shape of a triangle upon the head, which may be either brownish or green. This will distinguish them at once from the young of other species. There are characteristic blotches also upon the sides, and the legs are proportionately very long.

These make up our Delaware County frogs. The museum should have specimens of all of them. It still lacks the adult green frog, the swamp tree frog, and two of the *Hylas*, four out of the ten native species.

But, to return to the sentiment with which we started out, the main thing is to try to learn more of the life histories of these creatures. Any one with time and inclination, let it be boy or man, girl or woman, is quite capable of doing good work for science in such lines. It is work, also, that is pleasant, and unmixed with

> "sorrow of the meanest thing that lives."

Therein it differs from this collecting and putting into bottles. Collecting and bottling may be necessary, but the really fruitful study of animals is something other, and something pleasanter — one may say, something more decent — than this.

PHONETIC CHARACTERISTICS OF THE ENGLISH VERB.

BY HENRY L. BROOMALL.

The significance of a sentence lies as much in the recognition of its several parts as verb, subject and object, each with its qualifiers, as in the knowledge of the substantive meanings of the words. Each language has its own grammatical formulæ for the arrangement or modification of words acting in the various relations they may logically bear to the whole proposition. In highly inflected languages, such as Latin and Greek, these relations are indicated by modifications of or additions to the end of the word. Thus the Latin sentence *Caesar vicit Pompeium* may also be written *Pompeium vicit Caesar*, or in any order that emphasis or euphony may suggest, because the Latin mind depended only on the varied termination for the grammatical relation of the words. *Caesar vicit Pompeium* and *Caesarem vicit Pompeius* expressed the same difference of meaning that English conveys by *Caesar conquered Pompey* and *Pompey conquered Caesar*. To the Latin mind these English sentences would be synonymous or equally senseless because the change of order of words or their position before or after the verb would mean nothing grammatically to a speaker of that language.

Modern English has discarded inflections so generally that verbs, adjectives and nouns subjective and objective are largely reduced to like form. We may *man a ship* or *ship a man*. Only in pronouns is a distinction of case-form still partly maintained. *He hit her*, when the proposition is reversed, becomes *she hit him*. But even here it is the position of the pronouns before and after the verb, rather than their change of form that makes the sense, because this position is essential and the form is not. *Her hit he*, said by a child or a novice in English, is intelligible, despite the objective *her* for subjective *she* and subjective *he* for objective *him*, because it conforms to the grammatical formula of our tongue. The uneducated continually use the wrong form of pronoun, *me* for *I* and *I* for *me*, *her* for *she*, and the like, but the position of the pronoun as to the verb is always correct. A few hundred years ago *you hit him* was as bad as *me hit him* is now, because then the pronoun of the second person plural had distinct case forms, subjective *ye* and objective *you*. It would seem, therefore, as if pronouns were in the process of discarding these changes of form, unnecessary to the sense, just as occurred in the case of nouns.

Similar processes in the development of English have brought its verb nearly to the same simple form. Where, formerly, mood, tense, number and person were indicated by appropriate terminations, making the verb and its relations apparent by its form, there are now left only the terminal *s* of the third person singular present indicative, the past *ed*, the participial *ing* and numerous irregular forms such as *is* and *are*, *was* and *were*, *has* and *have*. The uneducated speaker stumbles over these distinctions of verbal person and number as he does with pronouns; but, as with pronouns, the verb is always in the right place in the phrase to act as a verb. In short, the English speaker expresses the grammatical structure of the sentence by placing verb, subject and object in a certain order, formulated in his mind when he was acquiring his native tongue. This order varies to suit interrogation, negation and exclamation, but each variation is definite and clear.

But position as a means of indicating the relations of words has its limitations. As long as verb, subject and object consist of one word each, the means is perfect. But where there are more words, the mind is taxed to group them quickly under these essential divisions of the sentence. The full power or import of each word is not realized until it is apprehended as whole or part of verb, subject or object. A current newspaper says "Taft plans"—and at this point the mind vacillates. If the two words are to be grouped as making the subject, then we expect something like "have been made" for some purpose. But if *plans* is a verb, then the words are separately apprehended, and we expect an object, such as "his campaign." The paper, however, proceeds: "Taft plans fall"—and we are ready to interpret *Taft plans* as *the plans of Taft*, making the subject group, and *fall* as the verb, making meagre but complete sense. But the paper goes on: "Taft plans fall tours"—and again we must shift the groups: *fall* becomes an adjective qualifying *tours* and is shifted from verb group to object group, and *plans* again is shifted from subject group to verb.

In the course of a sentence, there is no proposition even suggested until a word is reached that is apprehended as a verb. Without a verb there may be naming, but there can be no real thinking. As soon, therefore, as a word appears in the sentence, susceptible, with what has preceded, of interpretation as a verb, the mind seizes the opportunity so to group it and thus complete the subject and verb of the proposition. The verb is the key to the sentence.

Therefore in English where verb, noun and adjective are so frequently of like form, a tendency to discriminate the verb by some peculiarity of form from other parts of speech might well be expected. This would not be a retrogressive change or a reversion to old inflections denoting person and such agreements and accidents, but simply some formal difference characterizing it as a verb in any given case.

The English vocabulary affords words exhibiting a distinction of phonetic form when used as different parts of speech, whereby English speakers appear to be unconsciously responding to this necessity or advantage of discriminating the verb as such. In these words the verb is distinguished by

(1) The place of the syllabic accent, as *to record'*, in contrast with *the rec'ord*, the noun;

(2) A secondary accent, as *the winds mod'erate"*, in contrast with *a mod'erate wind*, or

(3) A sonant instead of a surd final consonant, as *to use*, in contrast with *the use*, the noun.

These phonetic characteristics may be illustrated as follows:

(1) The Place of the Syllabic Accent :

As Verb	*As Noun or Adjective*
To accent′	The ac′cent
affix′	af′fix
annex′	an′nex
augment′	aug′ment
absent′	ab′sent
attrib′ute	at′tribute
comment′	com′ment
concord′	con′cord
conduct′	con′duct
compound′	com′pound
confine′	con′fine
compress′	com′press
conflict′	con′flict
concert′	con′cert
consort′	con′sort
contest′	con′test
contract′	con′tract
contrast′	con′trast
converse′	con′verse
convert′	con′vert
convict′	con′vict
convoy′	con′voy
collect′	col′lect
colleague′	col′league
commune′	com′mune
complot′	com′plot
confab′	con′fab
construct′	con′struct
counterbal′ance	coun′terbalance
counterchange′	coun′terchange
countercharge′	coun′tercharge
countercharm′	coun′tercharm
countercheck′	coun′tercheck
countermand′	coun′termand
countermarch′	coun′termarch
countermark′	coun′termark
countermine′	coun′termine
countermove′	coun′termove
countermure′	coun′termure

As Verb	*As Noun or Adjective*
To counterpar'ry	The coun'terparry
counterplot'	coun'terplot
counterpoise'	coun'terpoise
counterseal'	coun'terseal
countersign'	coun'tersign
countervail'	coun'tervail
counterwork'	coun'terwork
desert'	des'ert
detail'	de'tail
digest'	di'gest
decrease'	de'crease
discord'	dis'cord
envel'op	en'velope
export'	ex'port
essay'	es'say
escort'	es'cort
extract'	ex'tract
ferment'	fer'ment
finance'	fi'nance
frequent'	fre'quent
foreto'ken	fore'token
forecast	fore'cast
foreshad'ow	fore'shadow
foretaste'	fore'taste
gallant'	gal'lant
guarantee'	guar'anty
infix'	in'fix
import'	im'port
impress'	im'press
incense'	in'cense
invert'	in'vert
impact'	im'pact
interdict'	in'terdict
imprint'	im'print
increase'	in'crease
insert'	in'sert
insult'	in'sult
introvert'	in'trovert
inset'	in'set
interchange'	in'terchange

As Verb	*As Noun or Adjective*
To interline'	The in'terline
inlay'	in'lay
intercross'	in'tercross
interlink'	in'terlink
inlet'	in'let
interspace'	in'terspace
ingrain'	in'grain
intergrade'	in'tergrade
object'	ob'ject
outflow'	out'flow
outride'	out'ride
overburd'en	ov'erburden
overdress'	ov'erdress
overheat'	ov'erheat
overlay'	ov'erlay
overset'	ov'erset
overturn'	ov'erturn
outbreak'	out'break
outgo'	out'go
overflow'	ov'erflow
overis'sue	ov'erissue
overmatch'	ov'ermatch
overstock'	ov'erstock
overuse'	ov'eruse
outburst'	out'burst
outlay'	out'lay
outwork'	out'work
overcharge'	ov'ercharge
overhand'	ov'erhand
overjoy	ov'erjoy
overmeas'ure	ov'ermeasure
overstrain'	ov'erstrain
overwork'	ov'erwork
outcast'	out'cast
outlook'	out'look
overdraw'	ov'erdraw
overhang'	ov'erhang
overmount'	ov'ermount
oversupply'	ov'ersupply
outcry'	out'cry
outpour'	out'pour

As Verb	*As Noun or Adjective*
To overhaul'	The over'haul
overlap'	ov'erlap
overpow'er	ov'erpower
overthrow'	ov'erthrow
perfect'	per'fect
preface'	pref'ace
perfume'	per'fume
permit'	per'mit
prelude'	pre'lude
premise'	prem'ise
presage'	pres'age
present'	pres'ent
produce'	prod'uce
progress'	prog'ress
project'	proj'ect
protest'	pro'test
placard'	plac'ard
preconcert'	precon'cert
precontràct	pre'contract
prefix'	pre'fix
proceed'	pro'ceed
preclude'	pre'clude
pervert'	per'vert
purport'	pur'port
postdate'	post'date
postfix'	post'fix
record'	rec'ord
reëxport'	reëx'port
reprimand'	rep'rimand
rebate'	re'bate
reflex'	re'flex
retail'	re'tail
rebel'	reb'el
refuse'	ref'use
retrovert'	re'trovert
regress'	re'gress
reimport'	reim'port
subject'	sub'ject
suffix'	suf'fix
survey'	sur'vey

As Verb	*As Noun or Adjective*
To secrete′	The se′cret
sojourn′	so′journ
torment′	tor′ment
transfer′	trans′fer
transport′	trans′port
unite′	u′nit
underset′	un′derset
undercut′	un′dercut
uplift′	up′lift
underlay′	un′derlay
underline′	un′derline

To these is to be added another class of specimens wherein the real verb is composed of two words, a general verb and a specifying preposition or adverb, such as *to lock up*. They are here separated from the foregoing list simply because the grammarian and printer have accustomed us to consider the compounded words as a true compound in the noun but not in the verb. They write the parts either together or with a hyphen when a noun, as *the lockup*, but when used as a verb they write and parse the words as separate parts of speech, as *to lock up*. This is probably a result of the accent falling on the first syllable when used as a noun. A few writers, recognizing the fact that the two words are a compound when used as a verb, hyphenate them, writing, for example, *to make-up* as well as *the make-up*. Grammatically and logically, they belong with the foregoing list. The following are examples:

As Verb	*As Noun or Adjective*
To get up′	The get′-up
go by′	go′-by
go between′	go′-between
hold fast′	hold′fast
knock out′	knock′out
knock down′	knock′down
kick up′	kick′up
lock out′	lock′out

As Verb	*As Noun or Adjective*
To let off′	The let′-off
lock up′	lock′up
let up′	let′-up
look out′	look′out
lay out′	lay′out
make up′	make′-up
pull down′	pull′-down
rig out′	rig′-out
round up′	round′-up
run away′	run′away
run about′	run′about
set off′	set′-off
shut off′	shut′-off
smash up′	smash′-up
stand up′	stand′-up
send off′	send′-off
set up′	set′-up
set in′	set′-in
set back′	set′-back
set down′	set′-down
shake down′	shake′-down
shake up′	shake′-up
shut down′	shut′-down
stand by′	stand′-by
stand off′	stand′-off
stand still′	stand′-still
take off′	take′-off
take up′	take′-up
toss up′	toss′-up
wash out′	wash′out
wind up′	wind′-up

That this tendency to differentiate the accent of noun and verb is active in spite of the authoritative dictionary is shown by many words wherein the lexicographers have not yet acknowledged the accent of the noun as different from the verb, although the distinction is made colloquially, such as:

As Verb	*As Noun or Adjective*
To address′	The ad′dress

As Verb	*As Noun or Adjective*
To abstract′	The ab′stract
alloy′	al′loy
assay′	as′say
combine′	com′bine
discard′	dis′card
discourse′	dis′course
exhib′it	ex′hibit
exile′	ex′ile
incline′	in′cline
intrigue′	in′trigue
redress′	re′dress
reject′	re′ject
research′	re′search

(2) A Secondary Accent :

As Verb	*As Noun or Adjective*
To ad′vocate″	The ad′vocate
amal′gamate″	amal′gamate
artic′ulate″	artic′ulate
agglom′erate″	agglom′erate
an′imate″	an′imate
as′pirate″	as′pirate
asso′ciate″	asso′ciate
agglu′tinate″	agglu′tinate
appro′priate″	appro′priate
ag′gregate″	ag′gregate
approx′imate″	approx′imate
cognom′inate″	cognom′inate
condu′plicate″	condu′plicate
conglu′tinate″	conglu′tinate
cat′enate″	cat′enate
com′plicate″	com′plicate
confed′erate	confed′erate
con′gregate″	con′gregate
cor′relate″	cor′relate
cul′minate″	cul′minate
capit′ulate	capit′ulate

As Verb	*As Noun or Adjective*
To certif'icate″	The certif'icate
commens'urate″	commens'urate
concat'enate″	concat'enate
con'fiscate″	con'fiscate
con'jugate″	con'jugate
cor'rugate″	cor'rugate
car'bonate″	car'bonate
cir'culate″	cir'culate
compas'sionate″	compas'sionate
condi'tionate″	condi'tionate
conglom'erate″	conglom'erate
coör'dinate″	coör'dinate
degen'erate″	degen'erate
deoper'culate″	deoper'culate
discrim'inate″	discrim'inate
del'egate″	del'egate
depaup'erate″	depaup'erate
differen'tiate″	differen'tiate
devar'icate″	devar'icate
decol'orate″	decol'orate
def'ecate″	def'ecate
delib'erate″	delib'erate
der'ogate″	der'ogate
dimid'iate″	dimid'iate
du'plicate″	du'plicate
decor'ticate″	decor'ticate
defo'liate″	defo'liate
denom'inate″	denom'inate
des'olate″	des'olate
disappro'priate″	disappro'priate
eman'cipate″	eman'cipate
exas'perate″	exas'perate
emar'ginate″	emar'ginate
es'timate″	es'timate
emas'culate″	emas'culate
excommun'icate″	excommun'icate
elab'orate″	elab'orate
enu'cleate″	enu'cleate
exartic'ulate″	exartic'ulate
flag'ellate″	flag'ellate

As Verb	*As Noun or Adjective*
To ful′minate″	The ful′minate
fed′erate″	fed′erate
fol′icate″	fol′icate
for′nicate″	for′nicate
fim′briate″	fim′briate
grad′uate″	grad′uate
gran′ulate″	gran′ulate
gem′inate″	gem′inate
genic′ulate″	genic′ulate
illegit′imate″	illegit′imate
imper′sonate″	imper′sonate
ineb′riate″	ineb′riate
init′iate″	init′iate
interme′diate″	interme′diate
is′olate″	is′olate
illu′minate″	illu′minate
imp′licate″	imp′licate
incorp′orate″	incorp′orate
infat′uate″	infat′uate
imb′ricate″	imb′ricate
impro′priate″	impro′priate
in′sulate″	in′sulate
in′timate″	in′timate
im′panate″	im′panate
inanit′iate″	inanit′iate
individ′uate″	individ′uate
infu′riate″	infu′riate
in′tegrate″	in′tegrate
i′odate″	i′odate
laur′eate″	laur′eate
lac′erate″	lac′erate
legit′imate″	legit′imate
lixiv′iate″	lixiv′iate
lib′erate″	lib′erate
lor′icate″	lor′icate
lam′inate″	lam′inate
marg′inate″	marg′inate
mod′erate″	mod′erate
matric′ulate″	matric′ulate
mur′iate″	mur′iate

As Verb	*As Noun or Adjective*
To me′diate″	The me′diate
mu′tilate″	mu′tilate
mac′ulate″	mac′ulate
min′iate″	min′iate
nu′cleate″	nu′cleate
nu′merate″	nu′merate
nom′inate″	nom′inate
overes′timate″	overes′timate
ov′ulate″	ov′ulate
ob′ligate″	ob′ligate
oblit′erate″	oblit′erate
perpet′uate″	perpet′uate
post′ulate″	post′ulate
pred′icate″	pred′icate
punc′tuate″	punc′tuate
per′sonate″	per′sonate
precip′itate″	precip′itate
predom′inate″	predom′inate
pus′tulate″	pus′tulate
per′colate″	per′colate
pontif′icate″	pontif′icate
predes′ignate″	predes′ignate
pop′ulate″	pop′ulate
predes′tinate″	predes′tinate
propor′tionate″	propor′tionate
pal′liate″	pal′liate
per′forate″	per′forate
quadru′plicate″	quadru′plicate
quintu′plicate″	quintu′plicate
rad′icate″	rad′icate
rep′licate″	rep′licate
ratis′cinate″	ratis′cinate
ra′diate″	ra′diate
res′inate″	res′inate
regen′erate″	regen′erate
redin′tegrate″	redin′tegrate
retic′ulate″	retic′ulate
redu′plicate″	redu′plicate
rever′berate″	rever′berate
ru′bricate″	ru′bricate

As Verb	*As Noun or Adjective*
To se′riate″	The se′riate
stam′inate″	stam′inate
subor′dinate″	subor′dinate
sep′arate″	sep′arate
sub′limate	sub′limate
syn′dicate″	syn′dicate
sa tiate	sa′tiate
stip ulate	stip ulate
sat′urate″	sat urate
sin uate	sin′uate
sul′phurate″	sul′phurate
seg′regate″	seg′regate
sit′uate″	sit′uate
subdel′egate″	subdel′egate
superan′nuate″	superan′nuate
tab ulate	tab′ulate
trip′licate″	trip′licate
tri′furcate″	tri′furcate
terebinth′inate″	terebinth′inate
trit′urate″	trit′urate
ter′minate″	ter′minate
triang′ulate″	triang′ulate
tu′bulate″	tu′bulate
und′ulate″	und ulate
vermic′ulate″	vermic′ulate
vesic′ulate″	vesic′ulate

(3) SONANT FINAL CONSONANT :

As Verb	*As Noun or Adjective*
To abuse	The abuse
advise	advice
breathe	breath
braze	brass
behoove	behoof
bathe	bath
believe	belief
clothe	cloth
calve	calf

As Verb	*As Noun or Adjective*
To devise	The device
disuse	disuse
diffuse	diffuse
disbelieve	disbelief
excuse	excuse
effuse	effuse
glaze	glass
grease	grease
grieve	grief
graze	grass
gloze	gloss
house	house
halve	half
leave	leaf
live	life
loathe	loath
lose	loss
mouth	mouth
misbelieve	misbelief
mouse	mouse
misuse	misuse
misadvise	misadvise
overuse	overuse
prove	proof
profuse	profuse
reeve	reef
rise	rise
refuse	refuse
reprove	reproof
relieve	relief
shelve	shelf
save	safe
sheave	sheaf
stave	staff
serve	serf
strive	strife
sheathe	sheath

As Verb	*As Noun or Adjective*
To thieve	The thief
teethe	teeth
use	use
waive	waif
wive	wife
wreathe	wreath

In most of the specimens adduced, the verb has the older phonetic form. *Decrease′*, the verb, has a more original accent than *de′crease*, the noun. The sonant *th* in *breathe* is the old sound, of which *th* in *breath* is a later variation. Thus the phonetic change has occurred in the words when used as nouns and adjectives. The recession of the accent and the conversion of sonant *th* and *s* to surd *th* and *s* are phonetic changes regularly made in the development of English. The accent and sonancy of the verb, therefore, are instances of persistence against the general tendency of the language. Such persistence implies a condition requiring modification of the language and its evolutionary response.

That there is a real correlation between these phonetic characteristics and the verbal idea is evidenced not only by the number of the foregoing specimens, but also by the fact that these phonetic contrasts are never reversed. If there is a difference of accent, the verb has it at or nearer the end of the word. If there is a variation of surd and sonant consonant, the verb always has it sonant.

There must, therefore, be something about final accent and sonancy that says "verb" to the English linguistic sense. There must be some analogy between the action of a verb in the sentence, as apprehended mentally, and these phonetic peculiarities. In seeking this analogy, we first note that *record′* is a longer word in utterance than *rec′ord*, *mod′erate″* than *mod′erate*, and *breathe* than *breath*. To utter the words is sufficient to prove this statement without appealing to the details of the vocal apparatus which explain the fact. The pronunciation is more prolonged, extended or continued by the final accent and sonancy, and it therefore takes more time to utter these words as verbs than as nouns or adjectives.

Is the logical action of a verb, in contrast with other parts of speech, comparable to these phonetic characteristics?

A phrase or collection of words without a verb is nothing but name. It indicates this or that, but it has no "go" to it. With a verb something becomes the source of the action it names and something the object, and the verb represents what "goes on" and how and when. Thus *rec'ord* is a name, it is a thing fixed: *to record'* names a *rec'ord* in the making.

Perhaps then "extension" or "continuingness" in time expresses the quality which is common to the mental conception of a verb as a part of the sentence and to the phonetic effect of final accent and sonant consonant. If so, the phenomenon is an element of English grammar leading towards clearer expression of thought.

MINUTES OF MEETINGS.

August 6, 1908. — Regular Monthly Meeting, President T. Chalkley Palmer presiding. Reports of Curators and Officers. The committee in charge of the construction of steps at the rear door of the Hall reported the work completed and that the proper report concerning the same had been sent to the Deputy State Factory Inspector. The report of the Publication Committee for the three years which had passed since the beginning of the publication of the Proceedings was presented, accepted and ordered spread upon the minutes. At the conclusion of the business portion of the meeting, Dr. Trimble Pratt, on behalf of Dr. Howard H. Furness, of Wallingford, presented to the Institute a number of very fine specimens of pitcher plants, of the genus *Nepenthes*, from Sarawak, Borneo. These plants were collected by Mr. William H. Furness, 3rd, during his travels in 1897. The donation was heartily appreciated by the members, and considerable discussion took place regarding these strange plants. After further discussion upon minor scientific matters the meeting adjourned.

September 3, 1908. — Regular Monthly Meeting, with the President, T. Chalkley Palmer, in the chair. The usual monthly reports of Curators and Officers were received. After the usual business matters of the meeting had been disposed of, the discussion of current scientific matters was taken up. C. M. Broomall presented specimens from a fossil tree stump now on the grounds of the former Shortledge Academy, in Media. Inquiry brought out the fact that this stump had been brought from the coal regions of Pennsylvania about 1886 and placed in the ground on the lawn of the Academy in such a position as to have the appearance of an ordinary tree stump. One of the fragments chipped from the stump shows the impress of a fossil leaf upon it. Dr. B. M. Underhill presented specimens of sandstone rock from the Des Moines River Cliffs, Marion County, Iowa. E. V. Streeper, Jr., presented a fine collection of fossils from Moscow, New York. Lewis Kirk spoke at some length upon the comparative temperature curves throughout a series of years, quoting figures, etc. The matter of the programme for the Lecture Course for the coming Winter was discussed, and the following general committee, with power to select its sub-committees, was appointed: Robinson Tyndale, chairman; Henry L. Broomall and C. M. Broomall. On motion adjourned.

October 1, 1908.—Regular Monthly Meeting, with the President, T. Chalkley Palmer, presiding. The usual reports of Curators and Committees received. William H. Gutelius, of Wallingford, Pa., was elected to membership in the Institute. The Committee on the Winter Course of Lectures reported that the proper sub-committees had been appointed, and that matters looked promising for an interesting series of meetings. Donations to the Library in the shape of Smithsonian Publications, the *Fern Bulletin*, etc., were reported. Donations to the Museum were received as follows: Specimen of crane fly, from William B. Broomall, Jr.; specimen of calcite from William R. Newbold, Jr., the same having been dug up from the bottom of the Panama Canal; specimen of king crab, in perfect condition, caught near Atlantic City, from E. V. Streeper, Jr. After lengthy scientific discussion, suggested by the presentation of the specimens, the Institute adjourned.

October 8, 1908.—Adjourned Meeting. Lecture, "Food and its Relation to Health," by Dr. Ernest L. Clark.

October 15, 1908.—Adjourned Meeting. Illustrated lecture, "Industrial Germany," by Dr. Benjamin F. Battin, of Swarthmore College.

October 22, 1908.—Adjourned Meeting. Illustrated lecture, "The Roman Wall across Britain," by Dr. E. P. Cheyney, of the University of Pennsylvania.

INSTITUTE NOTES.

In Volume III, Number 3, of the PROCEEDINGS, mention was made of a supposed Indian millstone, now located on the property of Casper Garrett, Newtown Township, this county, which had been found in Crum Creek near Mr. Garrett's home. There seemed considerable doubt as to its really being an Indian stone. Since then there has appeared a piece of information which sheds some light on the subject and shows that the stone, if not made by the Indians, was at least used by them. Robert Lindsay, of this Borough, but formerly of Newtown, a man of some 80 years of age, says that when he was a young man living in Newtown he was acquainted with an old lady, Alice Fawkes, then about 95 years of age, who had frequently recounted to him that when she was a child her mother used to take her out walking and down to the "Indian Mill" to see the Indians at work grinding acorns, etc. The stone now in Mr. Garrett's possession was taken out of the creek opposite the site of this old mill. From other sources we have the information that the valley of Crum Creek, at this point, was a favorite spot for friendly Indians. The Institute is indebted to Adolphus Leland, of Media, for this bit of local history, which adds much interest to the question of the origin of this stone. Several members of the Institute are engaged in collecting data concerning this and other Indian relics of Delaware County, and will appreciate any aid in this direction. It is intended at some future time to publish an extensive article in the PROCEEDINGS covering this line of inquiry.

As noted elsewhere, the Museum of the Institute has recently had added to it a specimen of a king crab in perfect condition. It was captured alive near Atlantic City, but died shortly afterward. The shell is some seven or eight inches in diameter, and with its long, spiked tail it is a formidable looking creature. Those familiar with the king crab will remember that it consists of an almost round shell, somewhat like that of a turtle, with the short legs and breathing apparatus on the under side, and a long, sharp tail behind. A member of the Institute calls attention to an interesting function of this tail, over and above any use it may have as a weapon of defence. The creature, if thrown upon its back on the sand, by the waves or otherwise, would be as helpless as a turtle in like position, were it not for the long, stiff tail. With this it is enabled to get a purchase on the sand and turn itself over. The member above referred to has witnessed this operation, in aquariums, more than once.

The statement that a petrified tree stump in its natural position is to be found in the Borough of Media is one that may reasonably be expected to attract attention. Yet such a stump really exists on the grounds of the one time Shortledge Media Academy, and as it stands has every appearance of being an entirely local production. There is no question about its being a petrified tree stump and in its "natural" position. Unfortunately, however, inquiry discloses the fact that it had been brought down from the coal regions of Pennsylvania about 1886 and planted in its present position, simulating an ordinary tree stump. It is really a very handsome specimen of petrifaction, despite its being a scientific hoax.

An analysis of Media tap water, made in the laboratory of the Institute on October 10th, 1908, shows the following: —

Free Ammonia	.025	parts per	million
Albuminoid Ammonia	.081	"	"
Nitrogen as Nitrites	.001	"	"
Nitrogen as Nitrates	.575	"	"
Chlorine as Chlorides	6.0	"	"

In Number 1 of Volume I of the PROCEEDINGS will be found a series of analyses of various local waters, with which comparisons may be made.

T. Chalkley Palmer, President of the Institute, sailed recently from New York on a six weeks' business trip to France and England. He will be very much missed from the meetings of the Institute. In addition to attending to the necessities of business, we can rest assured that Mr. Palmer will keep a weather eye open for matters of scientific interest.

Dr. B. M. Underhill, Secretary of the Institute, has been appointed lecturer in zoology in the veterinary department of the University of Pennsylvania. The doctor is a graduate of that institution, and his appointment is a well merited recognition of ability on the part of the University.

The past summer has been a remarkable one for its low rainfall and for the great forest fires that have accompanied this state of affairs. Aside from the immediate destruction of timber, there results from the deforestization a diminution of average rainfall for the future. This again produces conditions still more favorable for further fires, and so on in a cumulative circle. The importance of the preservation of our timber lands cannot be too strongly insisted upon.

The Winter Course of Lectures of the Institute began with the first adjourned meeting of October. There will be one business meeting and three lectures every month throughout the Winter. The good attendance at these meetings shows how much the efforts of the Institute in this direction are appreciated.

The Institute has just had a number of sets of the PROCEEDINGS bound into book form. The three volumes so far issued make a very convenient volume to place upon the shelves. The last number of each volume of the PROCEEDINGS contains the proper title page and index.

Officers of the Institute:

President,	T. Chalkley Palmer
First Vice President,	Charles Potts
Second Vice President,	Henry L. Broomall
Secretary,	Dr. B. M. Underhill
Treasurer,	Carolus M. Broomall
Librarian,	Henrietta K. Broomall

Board of Curators,

Edgar T. Miller, Homer E. Hoopes and the Officers

Vol. IV, No. 2 January, 1909

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OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:
T. Chalkley Palmer, Chairman; Henry L. Broomall, Trimble Pratt, M. D.

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. IV, NO. 2 . JANUARY, 1909

FLORENCE.

BY JACOB B. BROWN.*

I have taken in hand to give you some impressions of Florence that have remained with me. For I am not one who has visited the place merely — I have lived there. My object is, as I think you will see, to avoid the book of travel style; touching rather upon such matters as residents only are apt to become acquainted with.

Be pleased not to expect accurate statistics or clean cut statements. Any one can get the figures he may desire or require — names, dates, heights, distances and cold facts of that kind — from sources which are within easy reach. If I must tell you the truth, I rather absorbed the place than studied it, during the years of my living there.

Beginning, therefore, with what comes uppermost, it was my fortune, my not unmixedly evil fortune, to pass a summer in the city, instead of fleeing to the cooler country, as foreign residents do almost of course; and so with my own eyes I saw, among other things, what any one at all conversant with the matter might have told me, that the true Florentine who is wealthy enough to do as he likes does not go to his *villegiatura*, or season of country residence, in the summer time, but in the Spring and Fall. The fact is, as I understand it, that he really can keep cooler and more comfortable in his city home during the summer months — June, July and August — than out at the villa. The practice is to close the windows tight, both sash and blinds, during the day, and set them wide open at night. Thereupon consequent is the firm, strong, permanent grating of all lower windows, the bars being so arranged as not to interfere with the movement of the shutters. The gratings, moreover, are so curved outwards at bottom as to allow of putting the head out of window, and even of putting children in the receptacle so formed, for their air and gentle play. These gratings, moreover, often are in the palaces of wealthy nobles, specimens of iron work which are real works of art. Those, for instance, on the Strozzi Palace.

---

* Deceased.

Old Filippo Strozzi was a merchant — *un negoziante per bene*. His descendants are nobles. Another marked difference is that these are poor, while he was enormously rich. He was so rich that, as is said, he lost by theft merely of one kind and another, to the value of seven hundred and fifty thousand pounds sterling, at a time when the pound sterling would purchase vastly more than it does now.

A story that is told of this old Strozzi gives a notion of one at least of the means by which he became so wealthy. At the time spoken of he already owned a large, costly palace, which is to be seen in a far corner of the Piazza de' Strozzi. But his needs required a larger house, and he in person was, early one morning, overseeing the workmen as they placed the huge blocks for the lower story of the new building. Along came a friend of his, a man only less rich than himself, with — as is said — his market basket on his arm ; but this I do not believe, for it seems to me a sounder economy for a wealthy man to send for what he wants than to go himself, even though he be cheated a little. At all events the friend, whom we may call what we please — say Tornabuoni — passed the time of day, and taking a crazia, the smallest coin of the Florentine issue, out of his pouch, dropped it into the soft mortar, saying : "There, Filippo, there is a lucky penny for you." "Good heaven, man!" said the other. "Are you mad? Do you want to go to the poor house, that you fling your cash about like that?"

The garrulous and discursive path, so to speak, by which you have been brought to this point, will give you an idea of what might be passing in the mind of any man if he should, as I did, spend many hours during the comparatively cool time of the night in wandering through the old, quiet streets. I say the old, quiet streets; the newer streets are not quiet by any means in the night and summer season. For once, as often happened before and since, there passed under our windows on the Piazza de' Pitti a band of men and women, perhaps twenty persons, slowly pacing along and singing to the guitar. The singing was good, the song was sweet, the music really delicious, as it floated into the room. "Oh," said a lady who was of our company, "I shall die if I have to go back to America to live!"

Episodically let me say that there was a groom who used to stand outside his stable door in the Borgo SS. Apostoli and sing "Sentinella vada bene" so ravishingly that I often made occasion to go round that way at the proper time. And again — not the same subject continued — one lovely, sunshiny morning in the winter time a regiment of 1700 or 1800 men was passing along the Lung' Arno. Their music was a quickstep, played on a single bugle, and blown out of the brass with such true, crisp, delightful joyousness as would have led any man to death or glory.

My wanderings — you will have to submit to a good deal of the first person singular — took me often into the Via de' Bardi, where Romola used to live. And here there is something really interesting to be seen, and which, I am sorry to say, I have not found noticed in any book. You shall mark, as you pass along, many shapely arches of cut stone, neatly filled up with similar masonry; the contours of the old entirely undisturbed, but only exactly reached — if I explain myself — by the new. On inquiry there came out a good deal about the old time Florentine palace. Its lower story not infrequently consisted on front and part of two sides of open arches. These were not free entrances by any means, but were barred by powerful, iron gratings. Through these could be seen, sitting in state in his court yard and surrounded by his family and retainers, the head of the house. For these dwellings were devised to harbor the many members, married and unmarried, of a huge kinship. What I saw, therefore, in the Via de' Bardi, was a goodly number of these palaces, virtually unchanged, but with the arches blocked up and the rooms allotted to suit the needs of later and wholly different indwellers. Wholly different, I may well say, for their present occupants, so far from being knights and nobles, are not now even always human.

To give you an idea, however, of how the buildings were put up: — A ham and beef shop, which had got into one of them, took fire, and blazed and sizzled and sputtered and frizzled away as hard as it could; but so entirely confident was everybody in the arched floors and stone stairways of old time, that those above looked down, and those over the way looked out at what was going on with no other feeling than that of amused interest. Sorry to say, I did not see the fire, but I saw the place shortly afterwards, and all the disturbance had to show for itself was thoroughly smoke blackened walls and the cinders of meat.

What I desire is that some person of great wealth and an original turn of mind should take one of these old structures in hand and "restore" it in the full sense of the word — knock away all the added mortar and brick, make the court yards and stairways look as they did six hundred years ago — and then, if he still have money to burn, not to burn it, but use it to buy a good deal of authentic, old time furniture and fit up his resurrected rooms with it. This has been done by government in the case of certain public edifices, as I shall have occasion to remark later on, also by private individuals in one or two instances. But I want more.

The Florentine is a most admirable mason. He has the best of materials; for the limestone round about is, as I am informed, all water lime; there is a mountain of unsurpassed building stone no farther off than Fiesole, and the sand for mortar comes out of the river Arno, which runs right through the city. Now the rocks that yield this sand are in the hills hard by. The sand has been rotted but little and is sharp. Every builder knows what this means. As a natural and necessary consequence the getting of sand from the bed of the river Arno is a separate and special industry belonging to a certain class of people, who attain great skill in their pursuit and make a steady living. It may sound a little queer, when one speaks of skill in digging sand, but it is so all the same. The sand is dug from a boat moored out in the stream. The boat is a keel boat, but is of great beam in order to be sufficiently shallow and yet allow of the necessary displacement. With a long handled shovel, altogether like those used for sinking the holes for telegraph poles, the sand is dug from the bottom with a peculiar jerk. As it comes up through the water it seems to be washed free from every particle of mould, and a boat load is from a ton and a half to two tons. Some of it is raised to the level of the high quay in the ordinary way by shovelling from platform to platform. But the greater part is taken to a point just above the lower dam (one of two dams built across the river to prevent smuggling) and tossed through a suitable opening in the solid wall of the stone quay. Where it goes I, honestly, do not know, probably into another boat. If so, that boat must float on a subterranean canal which has issue — I do not know where. But there is no mistake whatever about the hole and the sand tossed in. The work is going on every day and all day long, and is as much a matter of course as an ordinary city inlet in Philadelphia. So much so that I am ashamed to say I somehow took the whole matter for granted, and never made any inquiries.

One day on the New Lung' Arno the ground floor of a large building was being put in. The foundations proper had been laid in the usual way, but the builder had coolly cut the earth between them to the proper shape and laid the arches of the stone, ground floor on that as centring. When the arches were all hard and solid, the earth beneath was thrown out to make the cellar.

The vineyards and *poderi*, or farms outside the city, are all separated by high, massive, stone walls. A wooden fence of any kind is a thing never dreamed of. First place, it is no protection; second place, the ground on the steepish hillside must often be terraced; and, thirdly, firewood is sold by weight. Now to prevent any risk whatever of these walls being "hore" by frost, and at the same time to save material, they are built on arches. At suitable distances apart piers are laid below possible frost (no great matter); rough but wholly sufficient arches spring from one to the other of these, very little if at all above the level of the ground, and if there be daylight the space is filled in, in the ordinary way.

A large part, perhaps the larger part of the houses in Florence, are *bona fide* fire proof. For lath and plaster are unknown; the stairways are of stone, the ceilings brick arches and the roofs always of tile. These same brick arches are miracles of the builders' skill. I should have said tile arches. First, some of you shall remember, and the others shall be informed, that the Roman brick which is used in Florence has about the same cubical content as ours, but the three dimensions are differently disposed. The Roman brick is thinner and wider than ours. And the tile used in the arches in question is thinner and much lighter than the Roman brick. No centering is used. The tiles are laid edge to edge, not flat side to flat side; and the binding material is plaster of Paris, not mortar. This sets so quickly that the work sustains itself as it grows, and it used to horrify me to see a man walk over an abyss, sustained only by an unkeyed vault. These vaults when finished are loaded with pretty fine building rubbish or any other suitable material in order to level them and distribute the pressure that is to come upon them. The thrust is so inconsiderable that they are safe to dance upon on what we should call the third story, and they call the second. If there be any doubt, the matter is mentioned in the lease, or else the giver of a large ball has set up at his own (inconsiderable) expense under the arch of his dancing room floor a balk of timber which is kept for the purpose. This is an ordinary domestic event and the men who do the work are as skillful as telegraph linemen in this country.

Let me mention here incidentally that, in the earthquake of 1894 or '95, I forget which, and it does not matter, not a few new buildings in the city were shaken and damaged, but very few old ones. What would you have? The walls of some of these are six feet thick — solid, stone masonry. One such, on the Sta. Trinità Square — it is now an hotel — has written over the door,

Per non aver dormito,

"For not having slept," or rather, let us say, for having been awake. And the story is that a cargo of wool arriving at Ravenna, a company of merchants set off from Florence on horseback to buy it. They, of course, stopped over night more than once on the way, and at a suitable point one of them, while the others slept, took horse, pushed on to Ravenna and bought the whole cargo himself. He made such a sum of money out of the transaction that he built with it the palace in question, and naïvely put the record of his sharp practice over the door.

This is, of course, mere physical force building, but there are feats of skill to be seen, unique and most impressive. The tower of the Palazzo della Signoria — House of Lords, if you choose — usually known as the Palazzo Vecchio, is built to overhang the wall of the main building about a yard — rising to the height of 150 feet or so above this overhang, and producing an effect which the great Ruskin most aptly designated as "scowling," rather than the usual and commonplace "frowning." Most consummate skill and daring on the part of him that did the work. His name is written in the brass and stone and parchment, but not in my faithless memory. The tower of the Palazzo Vecchio is a mere child in point of age when compared with the Campanile, but had that fallen the other day instead of this, the world would have lost a far more striking and important monument of the builders' art than it has done.

Take now the Bargello, as it is called, the Palazzo del Podestà. Built the usual number of years ago — say 500 or 600. A century or so, more or less, does not matter to such masonry. The council room which it contains is to my mind the grandest room I ever saw. From top to bottom, from end to end, and from side to side solid stone, with almost every adornment that can be made out of solid, cut stone — and no other. Not by any means overlarge. About such a room as the great waiting hall at the Reading Terminal would be if the floor were sunk to the ground level. Why one enormous iron ring, at least six feet in diameter, should be suspended from the soffit of the arch passes ordinary comprehension, but here are two such, and still the wonder grows. The Austrians occupied Florence for a while, and they turned this noble building into a political prison, putting floor after floor into the great Council Chamber and into the other stately galleries and apartments of the place. Amongst other things they whitewashed and walled in an inestimable portrait of Dante which was and is, one might almost say, world renowned. When they were turned out, the next thing was to turn their work out. With caution and good heed the task was entered on. "Ah, Signora," said the director of the work to Mrs. Anastasia Trollope, who wrote a loving description of the purifying process, "Ah, Signora, here is an amazing mass of *robaccia* (rubbish) to be pulled out; and if any one but old Arnolfo had built these walls we should have them about our ears; but we shall be all right — fear not."

Now as this portrait of Dante was known to every artist antiquarian there was wailing and gnashing of teeth when it was eclipsed. And it was my especial good fortune to hear from the original source how it was rescued. Being up at the Trollope villa, outside the Porta San Niccolo, one evening to make a visit, I fell in with Mr. Kirkup, an old English resident and a profound antiquarian. I had the honor of giving him my then youthful arm as a kind of steadier on the walk homewards, and you may be sure that I said no more than was calculated to keep him well going in talk about his favorite pursuit. He knew, as matter of course, about the portrait of Dante. He had, by consulting the books and by inquiries prosecuted with great caution, so as not to excite the suspicions of the jealous Austrian, located the portrait very exactly; and by vehement instance, not unaccompanied by money, had induced some one having the necessary authority to lock him up for the night in the cell which contained it. He had with him food, candle and some necessary appliances. Cautiously, very cautiously, he soaked off the whitewash, and there, sure enough, the portrait came out. A profile view in real fresco. He took a careful tracing of the head and face, which was all that could be done, and for reasons obvious to any one who will think a moment was very secret indeed about the treasure he had obtained. When it was no longer of any consequence who knew of the matter, he had his tracing engraved, and in my time, so to speak, it was to be seen in the better class of picture shop windows. In these later times not so much so. But those who saw it then would wonder why there was a queer, irregular patch or blotch, or whatever one may choose to call it, under the eye. Mr. Kirkup told me. It seems a nail had been driven into the plaster at that spot. When the time came to extricate the picture, Mr. Kirkup implored those in charge to let him deal with the difficulty. But no. They knocked the nail out and, as he said with bitterness, had not the sense to preserve the little pieces of plaster that fell to the floor. So the defect had to be borne with and, so to speak, recorded. The little hole has been filled up, and the picture "restored" as best it might be. But except as a landmark it has no more interest than an expurgated Bible or Shakespeare. Not being the original, it may be anything.

Be that however as it may, the Palazzo del Podestà has been restored whole as it was and with the lordly room spoken of above, the passages, the lesser apartments of state, and above all, the courtyard with its lilies and carved shields upon the walls, its gallery and its staircase, which, if altered in any way would be less or more than perfection, is one of the joys of the whole earth. The building is only the better for being used as a museum of choice and rare historical objects.

You have had a good deal of stone and mortar. But architecture is my favorite art, and I am going to give you a little more. The Baths of Lucca is a watering place much frequented by the Florentines, and a bridge over the Serchio, near the Baths, may fairly enough have a place in this reading. It was built by Narses, the general of Justinian, nine hundred years ago and more. It leaps high over the river, which is periodically flooded, and is of one arch only. The roadway is wide enough for two men on foot to pass, but not for two loaded asses. We used, of course, to call it the "asses' bridge." It is so slight that if one stand in the middle and "jounce," the bridge can plainly be felt to shake, yet there it is; and there seems to be no reason why it should not see yet many, many generations out.

The Duomo of Florence, the Cathedral Church of Santa Maria del Fiore, was after a hundred years of work roofed over and fit to worship in, but the cupola was not yet on. Arnolfo was dead, and the very practical question arose, what centering was to be used in turning the arch of the great dome which the master had projected. Structure of wood all the way up from the floor? An awful business, indeed, and doubtful enough. A heap of earth with coins thrown in, so that the poor people would come when the work was done, and carry all away for the sake of what they might find?

Hardly. Although the thing was to be made a lottery, and fair, fat, well grown, golden coins were to be put among the copper ones. Then did men turn to the great Brunellesco, who stood forth and said: "My master, Arnolfo, has built piers which set thrust at defiance, and I will turn the vault without centering."

I was caused to understand somewhat in the following manner how he made good his words.

Conceive a series of rings, automobile tires if you choose, the second a little smaller than the first, the third a little smaller than the second, and so on, the decrease not being sufficient to allow one to fall through the one preceding. Pile these up in their order, and a beehive shaped erection will result, which may be crowned with a ball. The "rings" of the masonry vault are circular construction in arch fashion, each voussoir inclining downwards to the proper extent, but prevented from falling through by its wedge shape. This is the whole matter. Modifications of detail are introduced as occasion serves. The fact is that the cupola is a double shell, probably because in this form it is stronger and lighter. But the soul exalting fact is that this dome is as nearly in a condition of stable equilibrium as such a fabric can be. It stands of itself, and is in no peril at all. Whereas the dome of St. Peter's is for necessary security bound about with links of iron so titanic that it is almost a wonder how they could be forged in days when steam hammers were unknown.

You should hear the affectionate intonation with which a Florentine will talk of Padre Arnolfo, Padre Brunellesco, Padre Alighieri and the other great masters which his city has evolved.

And now to show that some things can be done as well as others.

In 1876 I made a visit to Florence. At that time the arches of the Loggia of the Uffizi required repair. The city government was on the point of shutting up and boarding off the whole place for a season. But some one was found who shored up and repaired arch after arch without obstructing traffic. This was pointed out to me as a remarkable piece of building — to me, who now live within two miles of where the wooden trusses and stone piers of a bridge eighty feet high and a quarter of a mile or so long were taken out and replaced by iron towers and trusses, and never an hour of interruption to traffic — to me, who saw yonder Pennsylvania Railroad station changed from what it was to what it is, and never a train delayed — to me, whose countrymen moved the other day a tunnel, bodily, fifteen feet west by north, half north northerly, because it was cheaper to do so than to take down and rebuild.

A walk now about the city on the Oltr' Arno, or southern side. I could use up all the time you have to give me in telling you pleasant things about this somewhat active afternoon walk, but there are other things which I remember just as kindly, and I will only ask you to stop at the Torre del Gallo. So called because of a massive iron rooster which, set up on the tower, serves as a weathercock. He has a bullet hole through him. It is an interesting, old, hill castle, which I long to tell you about, but must not. The view is what I am thinking about. It looks eastward, far up the Arno, Vallombrosa way — across the Arno, Fiesole way — westwardly, down the Arno, Prato, Pisa and Leghorn way — and centre-of-the-earthwardly right down upon thick crowded Florence. To see this close stowed town, with the Cathedral and Giotto's Tower, the Palazzo Vecchio, the Bargello, Old Santa Croce and a score of other monuments, to each of which I owe an apology for not mentioning it here — to see all this melt away like widening water circles into thick strewn villas, and so into mere dim distance, is a picture which will last me, as Hamlet says, "while memory holds her seat in this distracted globe."

But the poet has set it all out long and long ago: —

> A veder pien di tante ville i colli,
> Par ch' il terren ve le germogli come

Vermene germogliar suole e rampolli.
Se dentro un mur sotto un medesimo nome
Fosser raccolti i tuoi palazzi sparsi,
Non ti sarian da pareggiar due Rome.

"Florence, to see thy hills full of so many wealthy, country homes, 'twould seem as if the earth did teem with them, as with its caterpillars and its flower buds it teems. If circled by one wall and all by one name known thy scattered palaces could be, two Romes were not to be compared to thee."

There is a Florentine custom connected with this present New Year season which may interest you. The admirable custom of caring for poor people's children while the parents are out at work for the day is a very old one in Europe, and in happy hour is becoming more and more established in this country. Accordingly the Asilo Infantile is a highly respected institution, and is the recipient of many donations. Among them this one. The duty of paying New Year's calls being sometimes inconvenient and even burdensome, people are allowed to commute. They pay three lire to the Asilo Infantile and for this consideration their names are posted in certain fixed and well known public places. Whoever finds a friend's name so posted understands that that friend wishes him a Happy New Year.

And the Asilo Infantile is not to be confounded with the Innocenti, or Foundling Hospital, which is a portentously large and important foundation. Little creatures left there, unless otherwise provided for, are apt to have the surname "Esposito," or "abandoned." My deft and clever servant was Esposito because he was a foundling, and Domenico because it was on a Sunday when they thrust him through the hole in the wall, rang the bell and ran away. Sometimes the child gets merely a number for a name. The great Florentine dentist, Trentuno, or Thirty-one, was in this class. He became a *ciarlatano di piazza*, and for years was seen on his wagon in the Square, pulling out teeth by the score, with that astounding skill and quickness which such men acquire and which must be seen to be believed in. Same forceps for all teeth and all patients, and not a drop of water anywhere within reach, if I explain myself. It did so happen that the Archduke of Tuscany was suffering dreadfully with the toothache one night, and nobody could be found to lend aid but the charlatan Trentuno. He, however, operated on the august patient with such cool nerve and consummate skill that his fortune — no small one — was made from that hour.

Florence has lost some flavor and gained much advantage by the clearing out of the old, interesting, filthy city around the Mercato Vecchio and the replacing of the greater part by fine, wide, handsome streets. Pretty far back in the centuries there stood in this time honored, time soiled part of Florence a handsome palace, and connected with this house is a Florentine story which I should like to tell you. In order to do so I must leave by the wayside much that appeals to my affectionate remembrance.

It is a true story in all essential particulars as I shall relate it for you. So I have at all events been assured. I have not seen the record among the archives of the city of Florence, but it is said to exist, and the matter is one of common talk. I know perfectly well the street, called not exactly but nearly enough by the name to be mentioned in due time.

The form in which you shall hear the tale is the one given it by Miss Sarah Woolsey, known in literature as Susan Coolidge, and this lady has, as I think, achieved the rare success of recasting in her own language and discreetly modifying the severe simplicity of an impressive story without diluting or enfeebling it.

When you hear that it is "The Story of Ginevra" you must not, as I for an instant was inclined to do, suppose that it is only another version of that of the poet Rogers, the well known and tragical history of a young creature who entombed herself in a spring closing chest on her wedding eve.

A somewhat similar circumstance is said to have occurred in Normandy not so many years ago.

An old lady whose last hour is near at hand is speaking to her little grand daughter: —

So, it has come! The doctor's glossy smile deceives me not. I saw him shake his head, whispering, and heard poor Giulia sob without, as slowly creaking he went down the stair. Were they afraid that I should be afraid? I, that have died once, and been laid in tomb? They need not. Little one, look not so pale. I am not raving. Ah! you never heard the story. Climb up there upon the bed, sit close and listen; after this one day I shall not tell you stories any more.

How old are you, my rose? What! almost twelve—almost a woman!

(A rather remarkable misconception seems to exist in the minds of some with regard to this matter of age. It is quite true that in tropical countries what we should call a child of twelve is "almost a woman." But it is not so at all in Florence, which is in latitude 43° north, or rather, nearly 44° — the parallel of Portland, Maine, pretty nearly.—J. B. B.)

Scarcely more than that was thy fair mother when she bore her bud, and scarcely more was I when long years since I left my father's house a bride in May. You know the house — beside the St. Andrea's Church. Gloomy and rich it stands, and seems to frown on the Mercato humming at its base, and holds on high, out of the common reach, the lilies and carved shields above the door; — and higher still to catch and woo the sun a little loggia close against the sky. That was my place ever as a child, and with me used to play a kinsman's son, Antonio Rondinelli. Ah! dear days. Two happy things we were, with none to chide or hint that life was anything but play.

Sudden the playtime ended. All at once "You must be wed!" they told me. "What is wed?" I asked, but with the word I bent my head, let them put on the garland, smiled to see the glancing jewels tied about my neck; — and so, half pleased, half puzzled, was led forth by my grave husband, older than my sire. Oh, the long years that followed. It would seem that the sun never shone in all those years, or only with a sudden, troubled glint flashed on Antonio's curls as he went by, doffing his cap with eyes of wistful love raised to my face, my conscious troubled face. Were we so much to blame? Our lives had been turned together, none forbidding, for so long. They let our childish fingers drop the seed, unhindered, that should ripen to full grain. They let the firm, strong roots tangle and grow, then plucked them, careless that they hurt the plant. I loved Antonio, and he loved me.

Life was all shadow, but it was not sin. I loved Antonio, but I kept me pure. Not for my husband's sake, but for his sake, my child, my little child, mine for a few short weeks, whose look, whose tone, thrilled all my soul, and thrills it to this hour. I loved, but hear me swear, I kept me pure. Remember that, Madonna, when I come before thy throne to-morrow. Be not stern, nor gaze upon me with reproachful look, making my little angel hide his face weeping while the others turn glad eyes, rejoicing, on their mothers.

It was hard to sit in darkness while the rest had light, to move to discord while the rest had song, to be so young and never to have lived. I bore as women bear until one day soul said to flesh, "This I endure no more," uprose, tore clay apart. And what was blank before grew blanker still.

It was a fever — so the leeches said. I had been dead so long I did not know the difference, or heed. Oil on my breast, the garments of the grave about me wrapped, they bore me forth and laid me in the tomb, the rich, the beautiful, the dreadful tomb, where all the buried Amieri lie, beneath the Duomo's black and gloomy shade.

Open the curtain, child. Yes; it is night. It was night then when I awoke to feel that deadly chill and see, by fitful, ghastly gleams of moonlight through the grated door the coffins of my kinsmen round about. Strange, hollow echoes rang and echoed back, as struggling out of mine I dropped and fell. With frantic strength I beat upon the door. It yielded to my touch; some careless hand had left the latch half slipped. My father swore afterwards, with a curse, he would make sure next time. Next time! That hurts me even now.

Living or dead I issued, scarce sure which. High overhead Giotto's Tower soared. Behind, the Duomo rose, all white and black. Then pealed a sudden jargoning of bells and darkling down the street I wildly rushed, led by a little, cold and wandering moon that seemed as lonely and as lost as I. I had no aim save to reach warmth and light and human touch, yet still my witless step led to my husband's door — there stopped by instinct and I knocked and called. A window opened and a voice ('twas his) demanded, "Who is there?" "'Tis I, Ginevra." Then I heard the tone change into horror as he prayed aloud. The while I pled, "Oh, let me in, Francesco, let me in! I am so cold, so frightened; let me in." Then with a crash the window was made fast, and though I cried and beat upon the door and wailed aloud, no other answer came.

Weeping, I turned away and feebly strove down the hard distance to my parents' house. "They will have pity and will let me in," I thought. "They loved me and will let me in." Cowards! At the high window overhead they stood and trembled while I pled and prayed: "I am your child, Ginevra; let me in! I am not dead; in mercy let me in!" "The saints in heaven forbid," replied my sire. My mother sobbed and vowed whole pounds of wax to San Eustachio would he but remove that fearful presence from her door. Then sharp came click of gunlock; a long tube was thrust from out the window, and my brother called: "Spirit or devil, hence, or else I fire!"

Where should I go? Back to the ghastly tomb and the cold, coffined ones? Up the long street, wringing my hands and weeping low, I went. My feet were bare and bleeding from the stones, my hands were bleeding, too. My hair hung down over my shroud — so wild and strange a shape saw never Florence since. The people call the street through which I walked and wrung my hands the Street of the Dead Woman to this hour. The sleeping houses stood in midnight black, and not a soul was in the street but I.

At last I saw a little point of light, high over head in a dim window set. I had lain down to die, but at the sight I rose, crawled on, and with expiring strength knocked, sank again, and knew not even then it was Antonio's door at which I lay.

A window opened and a voice called out, "Chi è?" "'Tis I; Ginevra." Then I thought, now he will fall to praying like the rest and drive me hence. But in a moment more the bolts were drawn, and arms whose very touch was life lifted and clasped and bore me in. "Oh, ghost or angel of my buried love. I know not, care not which, be welcome here! Welcome, thrice welcome, to this heart of mine!" I heard him say, and then I heard no more.

It was high noontide when I woke again to hear fierce voices wrangling by my bed — my father's and my husband's. For with dawn, gathering up valor, they had sought the tomb and found me gone and tracked my bleeding feet over the pavement to Antonio's door. Dead, they cared nothing; living, I was theirs. Hot raged the quarrel. Then came justice in, and to the court we swept to try the cause — I in my shroud.

This was the verdict given: A woman who has been to burial borne, closed in, locked fast and left among the dead; who at her husband's door has stood and pled for entrance, and has heard her prayer denied; who from her father's house is urged and chased, must be adjudged as dead in law and fact. The court pronounces the defendant dead. She may resume her former ties, at will; or renounce them, if such be her will. She is no more a daughter or a spouse, unless she choose; but is set free to form new ties if so she choose.

Oh, blessed words! That very day we kneeled before the priest — my love and I — were wed, and life began.

Child of my child, child of Antonio's child — bend down and let me kiss your wondering face. 'Tis a strange tale to tell a rose like you. But time is short, and had I told you not haply the story might have met your ears from them, the Amieri, my own blood, now turned to gall, whose foul and bitter tongues will wag with lies when once my lips are dumb. Pardon me, Virgin, I was gentle once, and thou hast seen my wrongs. Now go, my darling; when they waken thee to tell thee I am dead be not too sad. I that have died once do not fear to die. Close by Heaven's gate my own Antonio sits, waiting, and spite of all the frati say I know I shall not stand long at that gate, or knock and be denied an entrance there. For he will start up when he hears my voice. The saints will smile and he will open quick. Only a night to part me from that joy! Jesu Maria, let the dawning come!

OUR LATIN PRONUNCIATION.

BY HENRY L. BROOMALL.

The pronunciation of a dead language is important only to the science of linguistics. But if the dead language is also a classic, transmitting to us the results of past culture, that transmission brings with it words and phrases of the tongue in which the thought was moulded, and words and phrases must have pronunciation to be effective. And further, such a classic tongue, bearing such import, becomes itself an object of study, first, for the purpose of discerning meaning, and second, for its own sake as an instrument of refined expression. To us Latin is not only this but much more. The alphabet, our terms and notions of grammar, philosophy and literature, have come to us by way of Latin.

In constant English use are such Latin phrases as *bona fide*, *vice versa*, *prima facie*, *pro tempore*, and abbreviations such as *etc.*, *viz.*, *A. D.* In the sciences Latin words and forms afford a definite, compact and systematic classificatory nomenclature. In uranography the stars are designated by the letters of the Greek alphabet, their names pronounced as Latin and applied numerically, with the names of the constellations to which the stars belong in the genitive case, as α Orionis, indicating the first star in Orion. In botany and zoology names are composed of two parts, the first designating the genus, and the second, an adjective or noun genitive or appositive, particularizing the species — the first part indicating that in which there is agreement, and the latter that in which there is distinction, from other specimens. And in anatomy, medicine, chemistry and pharmacy, Latin and Latinized Greek words, or compounds of them, used according to Latin grammatical rules, are extensively, though not as systematically, used as in botany and zoology. So, too, the lawyer and the churchman use many Latin terms in the technique of their professions.

The advantages of Latin for these scientific purposes consist in the stability of a dead language. The living language which a people inherit and speak is continually changing: old words acquire new applications; new words abridge the province of old; concrete terms rise to the abstract; specific terms become general; and different lines and planes of thought and action give different meanings to the same word. While this renders a living language equal to any emergency of thought among its speakers, moulding it to their peculiar characteristics of mind as they advance or retrograde in civilization, yet this very vitality makes it unsuitable for descriptive and distinctive names to record and convey precise meanings regardless of time and place. A dead language, with its grammatical forms and the meanings of its roots and words immutable, answers this requirement. And, moreover, for this purpose, the Latin, of all the dead languages known to us, is eminently the best. We thoroughly understand its grammar and we have much of its literature wherein the meanings of its words and the construction of its sentence are fully exemplified. And further, the course of events in Europe for the last two thousand years has made the Latin language the common heritage of the civilized world and a medium of thought among students of every tongue. Its succinct modes of expression are unrivaled, its letters are familiar to our eye, and their sounds and combinations easily accommodated to our system of phonetics.

There is therefore enough Latin alive to-day to warrant attention to its pronunciation from a practical point of view.

Observation of French, Spanish, Italian and German scholars shows that each accommodates his pronunciation of Latin somewhat to the phonetic peculiarities of his own tongue. Each has his own conception of the phonetic value of the letters of the alphabet, based on their use in his own language. Generally speaking, these phonetic values of the letters are much alike in the European Continental languages, as compared with their present sounds in English, and are closer to the old Latin sounds. The contrast, therefore, between the pronunciation of Latin by the Continental scholar, guided by his own language, and the pronunciation of Latin as scientific investigation has determined it for the time of Cicero, is not great enough to cause embarrassment. But in English, such great changes occurred in its phonetic development after its spelling had become fixed, that the divergence between sound and letter could be corrected only by respelling thousands of words, or, as actually occurred, by changing the sounds alphabetically associated with the letters. Thus when the spelling of *he* was fixed, *e* had the sound now given *a* and the word was so spelled because it was then pronounced almost as *hay*. When the sound represented by *e* in many words changed to *ee*, *he* could have been respelled *hi* because *i* then represented the sound *ee*. But it was easier to change our notion of the letter. The value of the letter followed the phonetic change, so that now *e* as in *he* is its normal English sound. Similar processes resulted in our now giving the letter *a* its value in *mate* instead of its old value still preserved in *father* and the letter *i* its value in *mite* instead of its old value shown in Dr. Johnson's pronunciation of *oblige* as *obleege*. English is also peculiar in the sounds given to some consonants such as *j*, *w* and *ti* before a vowel, as in *nation*. Hence our pronunciation of Latin, giving these changed values to the letters, became still more different from what must have been the Roman pronunciation.

The consciousness of the artificiality of this pronunciation produced its effect upon the writers and compilers of the books from which we are taught what little Latin most of us know. Then the schools began to teach the Continental method as well as the English method. The Continental method, however, was an unsatisfactory attempt to consolidate and methodize the modern Latin pronunciations of France, Spain and Italy. It never was certain in all details, but it at least was nearer the old Roman pronunciation than the English. Finally came the scientific study of language, investigating comparatively and historically the use of the alphabet, and then appeared what is known as the Romanic method of Latin pronunciation. It attempts to reproduce the pronunciation of the Augustan Age of Latin, and, barring our inherent inability to appreciate vowel quantity, is a pretty good imitation.

Thirty years ago the Latin School grammar presented these three methods of Latin pronunciation, the English, Continental and Romanic. The teacher generally adopted that one with which he had learned the language. Now the school book not only advocates the Romanic method, but in most cases gives no other method. No one may deny that this method is logical and scientific. Through its use only can real Latin be apprehended. To understand Latin literature the student must acquire and use it. For the study of language as a science, no other pronunciation can be considered.

But this pronunciation is not used for the phrases, abbreviations and scientific nomenclature already mentioned, Roman proper names, and the Anglicized or semi-Anglicized words of Latin origin now a necessary part of our vocabulary, although it is in relation to these that our school Latin is worth while to the most of us. Only a few have inclination and ability to pursue Latin to the scientific or literary depth wherein the Romanic pronunciation is essential. If only the Romanic method is taught in the schools, the student jumps into real life with *bona fide* ringing in his ears as *bona feeda*, *prima facie* as *preema fakia* and *vice versa* as *weekay wersah*. Sooner or later he may adjust himself to the English pronunciation of such of these phrases as he often hears. But if they are infrequently used in his line of life, he is always hampered with a pronunciation adapted only to the linguistic student, the Latin philologist, or — a Roman dead some nineteen hundred years.

In view, therefore, of the Latin "living" in the midst of English and the English words of Latin origin, the English method has a practical use. We submit that the English as well as the Romanic method should be taught in the school.

Which the teacher may use in class work is perhaps unimportant. But surely the student should leave the school thoroughly equipped to understand on hearing, and to pronounce in speaking and reading, those phrases, abbreviations, maxims, proper names and scientific terms, uttered with the English values of the letters, which perhaps constitute the only Latin he will ever need in ordinary life.

SOME ADDITIONS TO DR. FUSSELL'S LIST OF DELAWARE COUNTY PLANTS.*

BY FRANCIS W. PENNELL.

In the following paper I have attempted to give a few plants of Delaware County, additional to those recorded in Dr. Fussell's comprehensive list of three years ago. These plants have come to my observation especially in the course of botanizing tramps in the townships of Middletown, Aston and Concord. Occasionally the results of herbarium study have been given.

A number of the plants recorded are doubtless accidental omissions, a number due to different understanding of old genera, while a larger number are strictly new records to the county. Of the last, while some are native, most are introduced plants, seldom seen, perhaps weeds of the future, the first arrival of which is worth recording.

Most of the newly recorded species are represented by specimens placed in the herbarium of the Philadelphia Botanical Club, at the Academy of Natural Sciences, Philadelphia. The species were mainly determined there, and where herbarium results have been given they are based upon specimens either in the Club or Academy collections.

The nomenclature followed in this paper is that of Britton's Manual, Second Edition, 1905. This is the same as that of Dr. Fussell's list. In cases of difference, the nomenclature of Gray's New Manual, Seventh Edition, 1908, has been added in brackets.

With each record has been given such matter of habitat, local range and comparison with allied species, as may be of interest.

Among the plants doubtless accidentally omitted from Dr. Fussell's list are the following: —

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* "List of Delaware County Plants," by Linnæus Fussell, M. D., Volume I, Number 3, April, 1906.

1 *Dryopteris marginalis* (L.) A. Gray. [Aspidium marginale (L.) Sw.]
2 *Carex virescens* Muhl. [C. virescens swanii Fernald.]
3 *Carex laxiflora* Lam.
4 *Juncus marginatus* Rostk.
5 *Cerastium longipedunculatum* Muhl. [C. nutans Raf.]
6 *Ranunculus septentrionalis* Poir.
7 *Rosa humilis* Marsh.

The following plants are native. Many have long been known, but under different designations, and not distinguished from closely allied species. A few, as *Hydrocotyle ranunculoides* L. f. and *Lobelia puberula* Michx., have certainly not before been reported from the county.

1 **Asplenium angustifolium** Michx.

A small colony growing in a cold ravine in the Barrens of Middletown Township.

2 **Carex hystricina** Muhl.

Probably an accidental omission, though hardly a common plant.

3 **Arisaema pusillum** (Peck) Nash.

Seems quite distinct from *A. triphyllum* (L.) Torr., with which Robinson and Fernald reunite it. A smaller, in every way more slender plant, commencing to flower much later; leaves bright green, not pale beneath; hood of spathe deep brown to black within. Frequent in rich woodland swamps.

4 **Juncus secundus** Beauv.

A slender, tufted species, frequent on the Serpentine. Earlier flowered than *J. tenuis* Willd., with which it has mostly been confused. The record of *J. gerardi* Loisel. from the Serpentine at Newtown, should be changed to this species. Dr. George Smith's plant in the Institute collection is undoubtedly *J. secundus*. *J.*

gerardi is an abundant plant of the New Jersey salt marshes, but little known inland.

5 **Smilax pulverulenta** Michx.
[S. herbacea pulverulenta (Michx.) Gray.]

Commoner with us than *S. herbacea* L. Distinguished by its usually longer, more pointed, dark green leaves, not pale beneath, but somewhat puberulent on the veins beneath. *S. pulverulenta* is peculiarly a plant of dry to damp woodlands, while *S. herbacea* is a plant of wet spring heads, woodland swamps, etc.

6 **Sisyrinchium mucronatum** Michx.

A plant answering the description of this species is to be met with not infrequently on dry, sandy soil. Secane, Llewellyn, Wawa, etc. It is a small, densely tufted plant, narrow leaved, with lax inflorescence, and the spathe quite generally purple. Not so common as *S. graminoides* Bicknell [*S. gramineum* Curtis], which, with the likely exception of *S. angustifolium* Mill., is our only other species of the genus.

7 **Celtis crassifolia** Lam. [C. occidentalis crassifolia (Lam.) Gray.]

Judging by its scabrous leaves, our common tree is this species. A tree I take to be *C. occidentalis* L., with narrow, darker, smooth leaves, I know from along the bank of lower Chester Creek.

8 **Linum medium** (Planch.) Britton.

An erect leaved plant, rather frequent on dry soil. Wawa, Williamson, Village Green, Secane.

9 **Acer carolinianum** Walt. [A. rubrum tridens Wood.]

A tree with smaller, thicker, less toothed leaves than *A. rubrum* L. The common form of Red Maple in the pine barrens of southern New Jersey. Occasionally found with us. Specimens have been seen from Tinicum, and I know the tree inland, on the West Branch of Chester Creek, below Llewellyn.

10 **Acer negundo** L.

Native along the Brandywine about Chadd's Ford.

11 **Lechea racemulosa** Michx. [Lam.]

12 " **leggettii** Britton and Hollick.

The genus *Lechea* occurs frequently with us on dry, barren or sandy soil. Our commonest species seems to be *L. leggettii*. *L. racemulosa*, *L. minor* L., and *L. villosa* Ell., are also occasionally to be seen.

13 **Viola obliqua** Hill. [V. affinis Le Conte.]

14 " **papilionacea** Pursh.

These Violets both occur in this county, *V. obliqua* rather rarely, but *V. papilionacea* abundantly.

15 **Hydrocotyle ranunculoides** L. f.

A considerable colony in a sluggish stream in a meadow along the Brandywine, a mile below Chadd's Ford. A southern plant, here near the extreme limit of its range.

16 **Scrophularia leporella** Bicknell.

Frequent. Earlier flowered than the equally frequent *S. marylandica* L., and in my experience preferring meadow land or opener situations.

17 **Lobelia puberula** Michx.

On clay soil, along the township line between Bethel and Concord, near the Delaware State boundary. In company with *Liquidambar styraciflua* L., *Clethra alnifolia* L., *Eupatorium verbenaefolium* Michx., and other plants of Tinicum or southern New Jersey flora. A southern species, extending north to southern New Jersey. This record probably represents the limit of its range into the hill country of Pennsylvania.

18 **Solidago juncea** Ait.

A handsome, glabrous, early flowered species, occasional with us. Llewellyn, Marple, and in Chester Co.

19 **Aster schreberi** Nees.

Appears to be frequent here.

20 **Antennaria neglecta** Greene.

Probably common. A plant of dry, open fields.

21 **Helianthus grosseserratus** Martens.

Noticed by my friend, C. S. Williamson, at Secane, in company with *H. mollis* Lam.

The following introduced plants are additional to Dr. Fussell's list : —

1 **Bromus tectorum** L.

European. Becoming frequent along railroads, etc. Wawa, Lenni, Williamson.

2 **Commelina communis** L.

Asian, or also native of southern United States, if identical with *C. nudiflora*, as Robinson and Fernald assert. Abundantly introduced, apparently our only species of the genus. Dr. Darlington, in the "Flora Cestrica," Third Edition, 1853, notes the arrival and spread of this plant in Chester County, referring it doubtfully and erroneously to *C. angustifolia* Michx. (= *C. virginica*, L.) of the South. I have been able to find no specimen from Delaware County of *C. virginica* or of any other species, if *C. nudiflora* be not considered distinct.

3 **Fagopyrum fagopyrum** (L.) Karst. [F. esculentum Moench.]

Eurasian cereal plant, occasionally appearing in cultivated fields, or lingering after cultivation.

4 **Silene vulgaris** (Moench.) Garcke.
[S. latifolia (Mill.) Britten and Rendle.]

European. Occasional weed. Wawa.

5 **Silene dichotoma** Ehrh.

European. Occasional weed. Wawa, Newtown Square.

6 **Alsine aquatica** (L.) Britton. [Stellaria aquatica (L.) Scop.]

European. Occasional weed. Along the railroad at Cheyney.

7 **Barbarea stricta** Andrz.

European. Occasional or frequent weed. Marcus Hook.

8 **Roripa sylvestris** (L.) Bess. [Radicula sylvestris (L.) Druce.]

European. Occasional or frequent weed.

9 **Cleome spinosa** L.

Tropical. Occasional escape from gardens.

10 **Sorbaria sorbifolia** (L.) A. Br.

Siberian. Occasional escape from gardens.

11 **Euphorbia cyparissias** L.

European. More or less frequent escape from gardens to cemeteries, etc.

12 **Conium maculatum** L.

European. Occasional weed. Lima.

13 **Quamoclit coccinea** (L.) Moench. [Ipomoea coccinea L.]

Tropical American. Occasional on dump heaps, etc. Secane.

14 **Convolvulus japonicus** Thunb.

Asian. Occasional escape from old gardens. Wawa.

15 **Micrampelis lobata** (Michx.) Greene.
[Echinocystis lobata (Michx.) Torrey and Gray]

Native of eastern United States, but I believe wholly an introduction in Delaware Co. It is seen rather frequently in moist soil, especially about dump heaps and waste land.

16 **Helianthus annuus** L.

Native of the prairie States west of the Mississippi River. Occasionally escaped from or persisting after cultivation.

17 **Coreopsis tinctoria** Nutt.

Native of the prairie States west of the Mississippi River. Occasionally escaped from gardens.

18 **Artemisia absinthium** L.

European. Occasionally escaped from gardens.

19 **Centaurea jacea** L.

European. Occasional weed. Lima.

20 **Centaurea solstitialis** L.

European. Occasional weed. Wawa.

SOME REMARKABLE FISHES.

BY GRACEANNA LEWIS.

We are all more or less familiar with the fishes of the market, but the inland dweller really has little conception of the wondrous variety of the inhabitants of the seas, and the almost countless hosts which they number.

While new discoveries are almost yearly reported, ichthyologists number at least 12,000 living species of fishes, in addition to those now extinct. These 12,000 living species are arranged in about 200 distinct families, each differing in a certain degree from the other, but capable of being arranged into larger groups of related families.

In some of these the number of species is prodigious, the group of the Cat Fishes, for instance, numbering about 1000; whilst others, at one time including many, may at the present be represented by only a single living species.

An example of the latter kind is to be found in the *Albulidae*, or Lady Fishes, now abundant in the Gulf of California. These fishes are earliest known from the Cretaceous Period, having been represented by different genera from that time to the present day. They are related to the Tarpons and Milk Fishes, and their young, as well as those of the Conger (and some other) Eels, pass through a larval stage, in which they are extremely slender, band shaped and transparent. In this condition, when they are known as "Ghost Fishes," they are frequently thrown on the beach in great masses by the force of the waves.

In the genus *Elops*, of the Tarpon family, the young pass through a similar band shaped and transparent stage, as do also those of the *Chanoidae*, or Milk Fishes. The latter are found on most sandy shores of the Pacific and Indian Oceans, and are very abundant in the Gulf of California and among the Hawaiian Islands. It was one of the fishes cultivated in the artificial fish ponds of the old kings of these islands, in the time of their ascendancy.

The Lady Fish is a beautiful one, with brilliantly silver scales, and I have chosen it on account of the interest attaching to its band like, transparent, larval forms. It belongs to the Division of Soft Rayed Fishes, in which the fins are usually without spines, as do our Shad, Herring, Salmon and their allies, as well as the majority of our fresh water fishes, such as the Carps, Suckers and their relations.

In the group of the *Percoidea*, or Perch like fishes, the different families inhabit all seas except those of arctic regions. The family of the *Percidae*, or True Perches, which includes about 120 species, are however, inhabitants of fresh water, of cool regions in the Northern Hemisphere, most of them being confined to eastern North America, or to Europe.

The great majority of the family are the Darters, all of which are American. They are of small size and bright colors, some of them being the most brilliantly colored fishes known. Most of them prefer running water, and, when frightened or hungry, dart with great velocity by a powerful movement of the fan shaped front fins, which represent the front limbs of quadrupeds. They vary in length from one to ten inches, and belong to the great Division of Spiny Rayed Fishes.

What is of especial interest, however, is that in two different genera of the group of the Darters there are to be found species which, in their adult stage, are perfectly and beautifully hyaline.

One of these, *Crystallaria asprellus*, is found in swift currents of clear streams in southern Indiana, Illinois, Arkansas and Alabama. This is one of the largest of the Darters, and is considered as a singularly interesting fish.

Of the Sand Darters there are four different species, all of them pellucid. They inhabit sandy bottoms of clear streams, and bury themselves entirely, except the eyes and the snout, in the sand. Although transparent, they are with bright reflections, as in Bohemian glass, adding greatly to their beauty. These belong to the genus *Ammocrypta*, and are of moderate or rather large size, one about three inches in length being found in Lake Erie, and in streams in Minnesota, Kentucky and Texas. By its habit of burying itself in the sand by an instantaneous movement, it becomes of especial interest. The other species differ slightly, either in size, markings or habits, and inhabit the streams of more southern localities in some instances, but all retain their pellucid appearance, so different from other fishes.

Another example of transparency is to be found in a family very far removed from the Perches. This is the family of the *Liparididae*, or Sea Snails, one of the group of the Lump Fishes, which are provided with a sucking disc between their ventral fins, by which they attach themselves to rocks or other objects. In this family there are two genera of fishes with transparent bodies. The family includes forty different species, none of them being distinguished in this manner except *Liparis cyclostigma*, which is a large fish found in Bering Sea and adjacent waters, and is beautifully colored, and *Crystallichthys mirabilis*, or the wonderful "Crystal Fish," also of Bering Sea. The latter, like its relative, is a large fish, soft and gelatinous in texture, translucent, and showing colors of grayish or purplish and reddish, marked with many round spots.

There are transparent Jelly Fishes, and other creatures amongst the Invertebrates, but so far as I can recall, these are the only known Vertebrates which are pellucid. I know of no theory which explains their existence, since they occur in families of fishes otherwise normal.

Other curious fishes are those which recall the larval forms of the Lady Fishes and their relatives, in the band or ribbon like slenderness of their bodies.

Among the *Scombroidea*, or Mackerel like fishes, is one family, the *Trichiuridae*, or Hair Tails or Cutlass Fishes, which look like a flattened Eel, the tail being very long and ending in a point, and the backbone composed of about 160 vertebræ, while the body is as flat as that of a Flounder.

The head and mouth are large, the jaws being armed with strong and unequal teeth, giving them a ferocious appearance. They are surface fishes of tropical seas, and are swift and active swimmers. There are about six species known, one of which occurs in the western Atlantic, northward as far as Virginia, and on the Pacific side, occasionally in Lower California. The same species is abundant in the West Indies, where it is sensitive to climatic changes, becoming benumbed with the slightest cold.

These Cutlass Fishes are bright silvery in color, are without scales, and justify their ferocious appearance by being voracious feeders. They are nearly related to the Frost Fishes of the family *Lepidopodidae*, which are also band or ribbon shaped, but which retain the rudiments of a Mackerel like tail. Their habits are similar to those of the Cutlass Fishes, in which the tail ends in a fine, hair like point.

Near the last of the series of the Spiny Rayed Fishes is a group known as the *Taeniosomi*, or "Slender Bodied Fishes," consisting of three families, all of which are extremely slender in proportion to their width, being band or ribbon shaped, and are known as the "Ribbon Fishes."

In the first family, the Oar Fishes, or *Regalecidae*, the back or dorsal fin extends over the top of the head and there expands into a crown of eight very long curved spines, which are either reddish brown or red in color, and become a striking ornament; while the ventral fins are converted into two long, thread like streamers, extending backward for a long distance, the thin and flexible body ending in a pointed tail. They are thus described: —

"The fishes of the genus *Regalecus* are very remarkable, not only on account of their peculiar appearance and structure, but because of their enormous size. They have been known to attain the length of twenty feet, and it is more than probable that they grow very much longer, and that many of the creatures popularly identified with the 'Sea Serpent' are only large individuals of this type. Indeed, it is safe to assign to this group all the so-called 'Sea Serpents' which have been described as swimming rapidly near the surface, with a horse like head raised above the water, surmounted by a mane like crest of red or brown.

"They are so slender that one of them fifteen to twenty feet long may not be more than ten or twelve inches in depth, and nowhere more than one or two inches in thickness. Not very much is known concerning them, as they are deep sea fishes, coming to the surface at pleasure, or when driven in shore by storms; in the latter case usually in a mutilated condition, their flesh being tender and their bones exceedingly brittle. During the last century and a half that these fishes have been known, comparatively few individuals have been taken, while they have frequently been seen swimming in the open seas, their great size, undulating motion and projecting mane causing them to be mistaken for a 'Sea Serpent.' It is not known that more than one species exists."

At the same time it is interesting to remember that the late Prof. E. D. Cope, after compiling a large number of what he considered to be the most reliable accounts of the "Sea Serpent," considered it barely possible that a gigantic, swimming reptile, belonging to the *Pythonomorpha*, might still be in existence, although this group first appeared in the Cretaceous Period, and is not known to have continued beyond Mesozoic Time.

The second family of the Ribbon Fishes includes twelve species, and these are much better known and more abundant than the members of the first family. They inhabit the eastern Atlantic, the Mediterranean, and have been found as far west as Madeira and Cuba. They are also reported from South America, New Zealand and elsewhere. Young individuals from two to four inches in length are frequently seen near the surface, and these exhibit the most extraordinary development of fin rays to be observed in the whole Class of Fishes, some of them being several times larger than the body and provided with lappet like dilatations, delicate and fragile appendages, suited only to the calm of undisturbed waters at great ocean depths.

The third and last family of the *Taeniosomi* is founded on a single specimen of an extraordinary fish taken in the Atlantic between Cuba and Martinique in 1790, and preserved in the British Museum. This fish was so unlike any other that it required to be placed in a distinct family. It is not even certain that it belongs to the group of the *Taeniosomi*, but it appears to be more like these than other fishes, and, for the present, awaiting fuller knowledge, is classed with them.

This remarkable fish has a body eleven inches, a tail twenty-two inches, and a total length of thirty-three inches, only a little less than a yard in extent. It is silvery in color, and ribbon shaped. Its eye is large and turned forward. Its mouth is without teeth, its snout being long and probably fitted for sucking its food, as it is subcylindrical.

No immediate relationship has ever been shown to exist between the Lady Fishes and allies, with their band shaped young; the band shaped Cutlass Fishes and the Ribbon Fishes of the *Taeniosomi*. If any hidden clue exists, it must be in the ancestry of all these different lines of fishes, possibly in some extinct form which may never be traced. The facts here brought together are, however, suggestive, and open a wide field of thought and conjecture.

FLOWER PIGMENTS.

BY C. M. BROOMALL.

The brilliancy and variety of color of the flowers that surround us cannot fail to excite a desire to know something of the pigments that produce these hues. Unfortunately, however, this is a subject about which there is much to learn, as is evidenced by the comparatively scant literature relating thereto and the absence of a concensus of opinion regarding the chemical and physiological relations of the pigments.

In connection with the chemico-physiological side of the question it is interesting to call attention to certain color changes produced in flower pigments by very simple chemical means. These reactions have probably been noted by most students of plant physiology, and indeed it is only by reason of their commonness that they are of interest. As will appear later, they give promising food for speculation concerning the chemistry and physiology of plant life.

A few easily performed tests with the pigments as extracted from many kinds of flowers, both cultivated and wild, will exhibit certain reactions common to the flowers of a given color. Thus, if an alcoholic extract is made of the petals of a flower, we find it to exhibit, at least in the great majority of the cases, the property of changing color as the reaction of the solution changes. In other words, the alcoholic solution makes what chemists call an "indicator;" that is, a solution which turns one color when a drop of alkali is added, and another color with a drop of acid. These changes are correlated with the natural color of the flower experimented upon. In the tests by the writer, sodium hydroxide and nitric acid were found to be very satisfactory reagents, although care had to be exercised not to add an excess. Of course, other acids and alkalis will also answer.

A series of tests covering a very considerable number of both wild and cultivated plants indicates the color reactions which follow as applicable to the variously colored flowers.

Dividing the flowers into three color groups and testing the alcoholic solutions made from the petals of these three classes of flowers we find the following reactions : —

(1) Red and pink flowers—Green with alkali, red with acid ;

(2) Yellow flowers — Green with alkali, yellowish with acid ;

(3) Purple and blue flowers — Green with alkali, purple or blue with acid.

These reactions the writer has found to occur in solutions made from many kinds of flowers, both wild and cultivated, and the color changes are strong and delicate and capable of reversal back and forth a number of times. As regards Class 2, however, care must be taken not to add an excess of reagent.

While these reactions of course may not be true for all flowers, yet in no case did they fail to appear in the writer's extended tests. However that may be, for the sake of the interesting speculations that result, let us assume them generally true and see where we land.

In the first place we see that in all cases the color is green with alkali, while with acid the solution takes more or less the color of the mature flower as we ordinarily see it. Bearing in mind, however, the fact that purple is not a simple color, but a combination of red and blue, the reactions lead us to suspect that we are dealing with but three pigments, which are red, yellow and blue in the acid condition respectively. These, however, are the three primary pigments from which, by various combinations, all colors may be produced. Hence, granting the existence of one or more of these three pigments in the flower petals, we see how it is possible to account for all the varied hues of the flowers around us. So much for the physical side of the subject.

But a still more interesting thought results from a consideration of the physiological relations of the pigments. Thus, we know that all plants live, as it were, a dual existence.

That is, in sunlight they absorb carbon dioxide and exhale oxygen ; while at night or during great activity they live like animals, using up the oxygen from the air and producing carbon dioxide. These processes are always going on more or less simultaneously. During the time of flowering we know that the animal side of the plant is very active, as a considerable production of heat, which can only result from oxidation, is then found to occur in the flowers. This means that the flowers at this time are the seat of active production of carbon dioxide. But since this compound is acid in reaction, it follows that the pigments in the flower petals will take on that color which corresponds to the acid reaction ; that is, the flowers will assume the ordinary color as met with, depending upon what pigments are present. In the earlier life of the flower, however, when it is simply living with the vegetable side of life predominant, there is not an acid reaction due to the presence of carbon dioxide and the petals are green, as we find them in young flowers. If the more or less greenish petals of an immature red flower, for example, be placed in water slightly acidified, they will assume the red color of the mature flower. This shows that the pigment is already present, but that the reaction is not acid. There are probably other substances of acid reaction also produced in the maturing flower, but the mention of carbon dioxide will be enough to indicate the trend of thought.

The theory of the physiology of the pigments to which our speculations lead may be briefly summarized as follows: In the petals of the young flower there exist certain of the three primary pigments in certain proportions. The reaction is alkaline, however, or at least not acid, and no matter what pigments are present the color is green. But later, as the animal life of the flower becomes more pronounced and the bud matures, the carbon dioxide and other acid substances thus produced change the reaction of the juices of the petal to acid, and the red, yellow or blue color of the pigment or pigments develops and the flower gradually assumes its final hue.

As regards the chemistry of flower pigments but little is known and it is perhaps doubtful whether any of them have been isolated in the pure state. It is interesting to note, however, that despite their extreme susceptibility to change of reaction they are really quite stable. Thus, in some pansies (of the variety with both purple and yellow petals) which had lain between the leaves of an old book, boxed up and packed away with others since about 1860, the respective purple and yellow pigment reactions were shown very nicely. And again, a purple pansy which had lain pressed away in an envelope in a book since "Easter Sunday, 1847," according to the label, changed back and forth between green and purple almost as markedly as a fresh flower.

MINUTES OF MEETINGS.

NOVEMBER 5, 1908. — Regular Monthly Meeting. Vice President Henry L. Broomall in the chair. Reports of Curators and Committees, payment of current bills, etc. The Committee on Lectures reported the appointment of the following sub-committees for the season of 1908-1909: —

October — Mrs. C. M. Broomall, Henry L. Broomall
November — Dr. J. Miller Kenworthy, Dr. Trimble Pratt
December — C. M. Broomall, C. Edgar Ogden
January — Anne J. Darlington, Dr. B. M. Underhill
February — Robinson Tyndale, Dr. J. C. Starbuck
March — Homer E. Hoopes, Dr. E. D. Fitch
April — T. Chalkley Palmer, Edward V. Streeper, Jr.

After the business of the meeting Dr. E. D. Fitch exhibited specimens collected by him in the petrified forests of Arizona. Questions arose as to the cause of the variety of color exhibited in the specimens and also as to the cause of their lateral cleavage, but no explanation for these phenomena was forthcoming. On motion adjourned.

NOVEMBER 12, 1908.—Adjourned Meeting. Round Table Talk. Open discussion of subjects of natural and historic interest.

NOVEMBER 19, 1908. — Adjourned Meeting. Illustrated lecture, "A Bit of Western Wonderland," by Dr. E. D. Fitch.

DECEMBER 3, 1908. — Regular Monthly Meeting. Vice President Henry L. Broomall in the chair. Reports of Curators and Committees, etc. The Publication Committee reported that Volumes I, II and III of the PROCEEDINGS had been bound into book form and placed in the Library. Under the head of scientific business C. M. Broomall presented a living specimen of the Newt commonly called the Red Eft, picked up along the roadside near Crum Creek. A general discussion followed concerning the distinctions between salamanders and lizards and concerning Amphibia and Reptilia in general.

Specimens of Mexican Jumping Beans were exhibited. It was stated that the movement of these beans is caused by the larva of a moth which passes certain stages of its life therein. One of the beans shown had been cut open, and the liberated worm had spun a cocoon on the inside of the glass containing vessel. On motion adjourned.

DECEMBER 10, 1908. — Adjourned Meeting. Illustrated lecture, "Stellar Photography," by Dr. John A. Miller, of Swarthmore College.

DECEMBER 17, 1908.—Adjourned Meeting. Lecture, "The Territorial Expansion of the Spanish Language," by Henry L. Broomall.

JANUARY 7, 1909. — Regular Monthly Meeting, President T. Chalkley Palmer presiding. Reports of Curators and Committees. Albert S. Barker, of Media, was elected to membership. The usual current bills and miscellaneous business were disposed of. President Palmer, who had just returned from a trip abroad, exhibited a naturalist's collecting "pond stick," which he had purchased in England. He also presented a living specimen of a large lizard taken from a cargo of logwood from Port de Paix. C. M. Broomall called attention to the extreme northern declination of the moon at this particular time. A general astronomical discussion followed. On motion adjourned.

JANUARY 14, 1909. — Adjourned Meeting. Lecture, "Rabies," illustrated by microscopic specimens, by Dr. John Reichel, of the Veterinary Department of the University of Pennsylvania.

JANUARY 21, 1909. — Adjourned Meeting. Illustrated lecture, "A Trip to Jamaica," by T. Chalkley Palmer.

JANUARY 28, 1909. — Adjourned Meeting. Lecture, "Art Education," by Clarence Preston Andrade, of the School of Industrial Arts of Philadelphia.

INSTITUTE NOTES.

A movement is on foot in the Institute looking toward the division of the membership into two grades, scientific and lay. For years past there has been, as a matter of fact, such a division, and the proposition now is to recognize this in a formal manner. The actual scientific work of the Institute is carried on by a coterie of students, while the rest of the members do no more than lend their moral and financial support. The feeling has been growing for a long while that these workers should have in some way a recognition of their labors. It is proposed, therefore, to create a grade of membership to be known as Fellowship, to which only those shall be admitted who have done real scientific work for the Institute. This grade of membership would, of course, be only honorary, and not affect the legal status of the members in any way. It certainly seems reasonable to offer some such tribute of merit to those who spend so much of their time in the interest of science.

Dr. B. M. Underhill has recently presented to the Museum of the Institute a collection of twenty-four pieces of broken nails, screws and wire, taken from the reticulum, or "second stomach" of a cow. As is to be supposed, the animal died as a result of its overloaded stomach, and on post mortem the cause of the trouble was discovered. One of the pieces of wire had penetrated the stomach wall and into the pericardium, setting up inflammation and causing death. The cow had been housed in a new stable and it is supposed that the nails and screws had been dropped by carpenters and the wire chopped with baled hay. A trouble of this kind, the passing of a sharp, foreign body from the stomach to the heart, by reason of the close anatomical relations of the organs, is not uncommon. Veterinarians say that it is one of the easiest conditions to diagnose in the living animal.

Several of the members of the Institute have recently had the privilege of examining a very interesting historical record. This is a copy of the *Ulster County Gazette* (New York), of January 4th, 1800. This was the first newspaper published after the death of General Washington, and gives a full account of that event. The Librarian of the Congressional Library says there are but two authentic copies of this paper in existence. The copy referred to is in the possession of William J. Curriden, of Chester, Pa.

Owing to the increased interest taken by the members in biological and physical subjects, it has been deemed worth while to organize a Physico-Biological Section in the Institute. The intention is to carry on the regular weekly meetings of the Institute in an informal manner during the summer. In this way the collectors of the Institute will be enabled to exchange their finds and keep in touch with each other.

William R. Newbold, Jr., of Ancon, Panama, has just donated to the Institute a collection of photographs of the Canal region. These, together with those he has previously sent, make a very valuable historical collection. The photographs are fine ones, and have been very favorably commented upon by our amateur photographers.

The microscopic outfit of the Institute has just had added to it a "bull's eye" lens for illumination of opaque objects. This practically doubles the usefulness of the apparatus. The naturalists of the Institute find it especially convenient for work in their department.

James G. Vail, a member of the Institute, who has been in Germany for the past six months, pursuing a special course of study in chemistry, is expected to return home shortly.

Officers of the Institute:

President,	T. Chalkley Palmer
First Vice President,	Charles Potts
Second Vice President,	Henry L. Broomall
Secretary,	Dr. B. M. Underhill
Treasurer,	Carolus M. Broomall
Librarian,	Henrietta K. Broomall

Board of Curators,

Edgar T. Miller, Homer E. Hoopes and the Officers

Vol. IV, No. 3 April, 1909

PROCEEDINGS

OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:
T. Chalkley Palmer, Chairman; Henry L. Broomall,
Trimble Pratt, M. D., Charles Potts,
B. M. Underhill, V. M. D.

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PROCEEDINGS
OF THE
Delaware County Institute of Science

Vol. IV, No. 3 April, 1909

VOCAL IMITATION OF MOTION AND MASS.

BY HENRY L. BROOMALL.

It has been said elsewhere* that imitation is the basis of the acquisition and transmission of language. The child is born into a community where he finds a language already made and used, and his education largely consists in imitating the vocal sounds he hears and their meanings. His effort is properly to associate sound and meaning as he finds them already associated in the community around him. At first he stumbles over the articulation of the sounds and appreciates their meanings but vaguely. With vocal practice and mental advancement he gradually perfects his articulation and grasps the meanings more closely or thoroughly. By this process he generally finds all the language he needs. Why particular sounds and meanings are thus associated is a subject that neither aids him in this acquisition of speech nor interests him — if ever — until long after he has mastered the practical use of his language.

In some of the traditional forms of language thus imitated, the learner sooner or later feels — rather than appreciates — that he is also imitating sounds produced by the things or actions named. He learns the words *croak*, *crack* and

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*"Significance of Errors in Speech," Proc. Del. Co. Inst. Sci., Vol. I, No. 2, p. 30

creak, and he recognizes in the vocal sounds *ō*, *ă* and *ē** direct imitation of the character of the external sounds these words respectively represent. He perceives, perhaps vaguely, that *groan* and *grunt* somehow actually imitate the noises they name. He may go so far as to recognize the value of *kr* and *gr* as onomatopoetic elements. This direct imitation does not confine itself in the child to the words he hears. Objects of which some sound is the striking characteristic, such as a dog or bell, are named at first by direct imitation, as *bow-wow* or *ding-dong*. These names, however, generally give way later on to the words used for these things by the speakers of the child's environment.

We thus arrive at the starting point of the present study. The imitation which is the basis of language learning, as thus far considered, may be either (1) of the language around us, or (2) of other sounds around us; the former process being essential and predominant, the latter exceptional and restrained. These are well known principles acknowledged by linguistic students.

It is the purpose of this article to suggest that the imitation extends not only to the sounds of external objects, but also to their motion and relative mass.

This involves the proposition that, just as an external sound may be imitated by a vocal sound, so there may be movements and positions of the vocal organs, in making certain sounds, or in changing from one sound to another, which seem to the speaker to be correlated with the movements and relative mass of things he sees in the outside world. Motion and sound so frequently occur together in nature that a vocal sound may often be felt as referring to both and sometimes by one person as imitating the motion and by another the sound. While *croak* and *creak* may be considered as imitative of the contrasted sounds which the words name, yet some of their significance is due to the enlarged internal contour of the mouth in the utterance of *croak* as compared with the contracted position of the vocal organs in uttering *creak*. The first position of the vocal parts is felt as big, the second little. *Sput* is felt to be imitative of sound, but the *r* of *sputter* is not: if imitative at all, it is of repetition, and repetition is motion. *Tramp* and *trample*, if simply onomatopoetic, would have no distinction in their imitative significance. Yet we are conscious that there is in *trample* a quick repetition of motion that does not exist in *tramp*. One could *tramp solemnly*, but he could hardly *trample solemnly*. If, therefore, *tramp* imitates sound, the *l* of *trample* imitates motion. A *zigzag* makes no noise, but the contrast of vowel in the repeated syllable is somehow imitative of the changed direction or course in making the figure named, and this is a form of motion.

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* As this present article is non-technical, the diacritical signs of pronunciation adopted by the standard lexicographers are here used because they are generally known and because they are sufficiently accurate for general phonetic consideration.

It is to be understood in considering the examples to be produced that the etymological origin of the consonants or vowels imitating sound, motion and mass is not within the province of this study. Indeed, etymology must be ignored in order thoroughly to weigh the present imitative value of these sounds. Be their origin what it may, the sounds are felt by present speakers to be directly representative of certain characteristics of external objects.

The specimens illustrating the present proposition that motion and mass, as well as sound, are directly imitated, even in a cultured language such as English, may be grouped as follows: —

(1) Final *L* and *R* imitating quick, repeated, rotary movements, or things and effects produced by such movements, as *jiggle* and *jigger* compared with *jig*, and *whirl*.

(2) Repeated syllables imitating reciprocal, changing motion or opposing direction, or things and effects produced thereby, contrasted by having either

(a) Different vowels and the same consonants, as *seesaw*, or

(b) Different consonants and the same vowels, as *helter-skelter*.

(3) Contrasted words, in which different vowels are imitative of difference in volume of sound, mass or motion in the objects or actions the words name, as *squall* compared with *squeal* and *joggle* compared with *jiggle*.

(1) FINAL L OR R IMITATING QUICK, REPEATED, ROTARY MOVEMENTS, OR THINGS AND EFFECTS PRODUCED BY SUCH MOVEMENTS.

Final L.

amble

bungle
bangle
bumble
bubble
bustle
bristle
brittle

chuckle
cackle
cockle
coddle
crackle
cradle
crimple
cripple
crumble
crumple
cuddle
curdle

dabble
dandle
dally
dangle
dapple
dazzle
dibble
diddle
dawdle
dingle
doddle
drizzle
draggle
dribble
drivel
dwindle

entangle

fickle
fiddle
fizzle
fondle
freckle
fribble
frizzle
fuddle
fumble

gabble
gaffle
gaggle
giggle
gambol
garble
gargle
goggle
gobble
gurgle
girdle
grabble
grapnel
grapple
gravel
griddle
grizzle
grovel
grumble
guggle

hackle
haggle
hamble
handle
hobble
huddle
hurdle
hustle

jumble
jiggle
jingle
joggle
jostle
justle
juggle

ladle

mangle
meddle
mingle
mizzle
mottle
muddle
muffle
mumble
muzzle

needle
nestle
nettle
nibble
niggle
nimble
nobble
noddle
nozzle

nuzzle

ogle

paddle
pebble
peddle
pestle
piddle
pintle
pommel
prattle
prickle
puddle

quibble
quiddle

rabble
raffle
raggle
ramble
rankle
rattle
ravel
riddle
riffle
rumple
ripple
rubble
ruffle
rumble
rustle

scrabble
scrapple
scramble
scriggle
scuffle
scuttle
settle
schrackle
shrivel
shuffle
shuttle
sidle
sizzle
skedaddle
skittle
snaggle
sniffle
snuffle
sniggle
snuggle
spangle
sparkle
speckle
spindle
spittle
sprinkle
squabble
startle
straddle
straggle
strangle
struggle
stubble
stumble
suckle
swaddle
swivel
swingle

tangle
tassel
tattle
tittle
thistle
throttle
tickle
tingle
tinkle
tinsel
tipple
toddle
topple
toggle
tottle
tousle
trammel
trample
treadle
tremble
trickle
trifle
trackle
tumble
twaddle
twattle
tweedle
twinkle

wobble
waddle
waggle
warble
wattle
wheedle
whiffle
whistle
whittle
wimble
windle
wrangle
wrestle
wriggle
wrinkle

Final R.

blabber
bluster
blubber
blunder

chatter
clamber
canter
clatter
caper
chaffer
cluster
clutter
cower

dapper
dicker
dodder

flutter
flitter
falter
flicker
flounder
fluster
fritter

glimmer
garner
gather
gibber
glamour
glister
glitter
goffer
hamper
hanker
helter-skelter
hover

jibber
jigger
jabber

limber
linger
litter
loiter

mutter
meander
murmur
monger

patter
pelter
pester
pilfer
pucker
palter
palaver
pother

quiver
quaver

sputter

scrupper
scramper
smolder
spatter
splinter
stagger
stutter
swagger
swelter
saunter
scamper
scatter
shatter
shimmer
shudder
simper
skelter

slobber
slatter
slaughter
slaver
sliver
smatter
snicker
spalder
splatter
splutter
squander
stammer
simmer
sunder
swelter
tamper
tatter

tinker
titter
totter
trigger
twitter

utter

wander
waver
welter
whimper
whisper
wicker

yammer

Final RL.

birl
curl
dirl
furl

gnarl
hurly-burly
purl
swirl

shirl
snarl
twirl
thirl

tirl

whorl
whirl

(2) REPEATED SYLLABLES IMITATING RECIPROCAL MOTION OR OPPOSING DIRECTION, OR THE EFFECTS THEREOF, BY CONTRASTED VOWELS OR CONSONANTS.

Contrasted Vowels.

bric-a-brac
bibble-babble

chiff-chaff
criss-cross
chitchat
clinkum-clankum
clitter-clatter
crinkum-crankum

dilly-dally
dingle-dangle

ding-dong

flipflap
fiddle-faddle
fingle-fangle
flim-flam
flip-flop

gibber-gabber
gibble-gabble
giff-gaff

higgle-haggle

hip-hop
heehaw
hippety-hoppety

jingle-jangle
jimjam
jig-a-jog

kit-kat
knick-knack

mingle-mangle
mishmash

nidnod
niddle-noddle
nifnaffy

pickapack
pibble-pabble
pickpack
prinkum-prankum
prittle-prattle
pitapat

ribble-rabble
rick-rack
riffraff
riprap

seesaw
shilly-shally
skimble-scamble
scribble-scrabble
snipper-snapper
singsong
snip-snap
swish-swash
slipslop

twittle-twattle
tittle-tattle
tick-tock
titter-totter

teetotal
tit-for-tat
tric-trac
tick-tack
tit-tat-to
tip-top

wish-wash
wigwag
wiggle-waggle
wishy-washy

zigzag

Contrasted Consonants.

bow-wow

claptrap

flitter-gibber
flibberdigibber
fallal
folderol

hanky-panky
hodge-podge
humdrum
harum-scarum
hurly-burly
hubble-bubble
hoot-toot
hocus-pocus
hotch-potch
humpty-dumpty

helter-skelter
hubbub
hobnob
hugger-mugger
higgledy-piggledy
hoky-poky
handy-dandy
hoodoo
hurry-skurry
holus-bolus
hoity-toity
hurdy-gurdy

mumbo-jumbo

niminy-piminy
namby-pamby

powwow

pell-mell

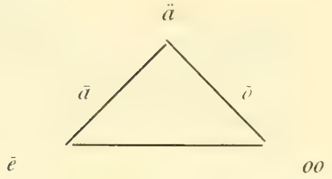
rat-tat
rumble-tumble
roly-poly
rat-a-tat
rubadub
ragtag
ruffy-tuffy
ragshag
rat-tat-too

slambang
slang-whang

tehee
titbit
ting-a-ling
tag-nag

(3) CONTRASTED WORDS IN WHICH DIFFERENT VOWELS ARE IMITATIVE OF DIFFERENCE OF SOUND, MASS OR MOTION IN THE OBJECTS OR ACTIONS THE WORDS NAME.

The accepted diagrammatic representation of the vowel scale, using the lexicographers' signs, is as follows: —



The place of *ä* (as in *father*) at the apex of the triangle suggests that it is uttered with the most open position of the vocal organs. The position of *ē* indicates that it is uttered with the most contracted position of the vocal organs as particularly felt in the back of the mouth. The position of *oo* is intended similarly to represent the other extremes where, while there is contraction of the lips, yet the general contour of the mouth is extended and the other vocal organs uncontracted. The speaker may run the vowel scale by beginning with *ē*, passing through *ā*,* *ä* and *ō*, and ending with *oo*. The *a* of *cat* will be heard as he passes from *ā* to *ä* and the *aw* of *flaw* as he passes from *ä* to *ō*. So all other possible pure vowel sounds lie between the extremes *ē* and *oo*.

The words of this list are comparatively arranged by placing first the word having the vowel made by the more contracted position of the vocal organs, as *ē* or its short equivalent *ĭ*, and then arranging other words of similar form and analogous meaning as their vowels are made by a more open position of the vocal organs or by a more enlarged contour of the mouth. As the vowels so open and enlarge in their method or means of making, so the sense of the words containing them enlarges. This comparison of size or mass expressed by vocal sounds is illustrated by the preservation of *teeny* as the pronunciation of *tiny* in such expressions as *wee*,

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*The diacritic signs for long "a" and long "o" may be misleading because in English these are generally diphthongs, the long "a" ending in a short "i" sound and the long "o" in a short "u" sound. The signs are here used as if the final short sound were not heard. The long "a" and long "o," as here used, are therefore respectively equivalent to long "e" and long "o" as heard in the Spanish and Italian.

teeny bit. The present pronunciation of *tiny* is with long *i*, and that sound of *i* is the regular result of English phonetic laws, yet when the speaker wishes more strongly to emphasize littleness he persists in the old sound *ee* because the more contracted position of the vocal organs in making this sound is more expressive and imitative.

The progression from vowels made by contracted position of the vocal organs to vowels made by open and extended position of the vocal organs is shown by the following series of specimens. This progression is approximately *ē*, *ĭ*, *ĕ*, *ā*, *ă*, *ŭ*, *ŏ*, *ä*, *au*, *ō*, *oo*.

Contrasts of four or more words.

creak, crick, crack, croak
check, chuck, chock, choke
click, cluck, clack, clock

diddle, daddle, dawdle, doodle

fleet, flit, flout, float

gleam, glim(mer), glamour, glum, gloaming, gloom

nib, neb, nab, nub, knob

pale, pile, pole, pawl

stick, stack, stock, stake, stalk, stoke
sweep, swop(b), swap(b), swipe, swope, swoop
skit, scat, scud, skate, scout, scoot
seep, sip, sap, sup, sop
spit, spat, sput, spot, spout
slish, slash, slush, slosh
spear, spur, spar, spire
shack, shuck, shake, shock
streak, strake, strike, stroke
strip, strap, strop, stripe

Contrasts of three words.

beat, bat, but
biff, baff, buff
back, buck, balk
babble, bubble, bawble
bubby, baby, booby
chip, chap, chop
cap, cape, cope
cry, crow, croo

drip, drop, droop
dab, dub, daub

flee, fly, flow
flip, flap, flop
fie, faugh, phew

giggle, gaggle, guggle
grin, grunt, groan
grip, gripe, grope
grits, grouts, groats

jig, jag, jog
jiggle, juggle, joggle

knick, knack, knock
knit, net, knot

lip, lap, lop

mell, mull, mawl

peep, pop, poop
peak, pick, poke
pit, pet, pat
pick, peck, pock

piddle, paddle, puddle

reed, rod, rood
rip, rap, rape

sneer, snarl, snore(t)
slit, slat, slot
sneak, snake, snook
slip, slap, slop
sniggle, snaggle, snuggle
snib, snub, snob
sniffle, snaffle, snuffle
step, stop, stoop

trail, trawl, troll
tang, tongue, tong
tick, tack, tuck
tweedle, twiddle, twaddle
tit, tat, tot
tip, tap, top

whiff, wave, waft
whip, w(h)ap, wipe

yell (yelp), yowl, yawl (yawp)

*Contrasts of two words.**

blink, blank(ch)
bish, bosh
biff, buff
bat, but
back, buck
baff, buff
bilk, balk
blear, blur
bum (bomb), boom

crimp, cramp
clink, clank
clip, clap

chitter, chatter
chilled, cold
cuddle, coddle
crash, crush
caw, coo
drag, drogue
damn, doom
deal, dole
dint, dent
dribble, drabble
dip, dope
flicker, flacker

flipper, flapper
flitter, flutter
flash, flush
grit, grate
ghastly, ghostly
gap, gawp
gad, goad
gurgle, gargle
grave, groove
hitch, hatch
higgle, haggle
hiss, hush

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*Contrasts of three words occurring in the list of contrasts of four words, and contrasts of two words occurring in the lists of three and four words, are not repeated in the lists of three and two words respectively. The contrasts of two and three words are therefore actually much more numerous than they appear in those lists.

hear, hark
harsh, hoarse
hail, howl

jingle, jangle
jilt, jolt
jet, jut
justle, jostle

leap, lope
leash, lash
least, less
lull, loll
leer, lower

miff, muff
mash, mush
munch, maunch
meddle, muddle
mite, mote

nip, nap
nibble, nobble
nig, nag
nitch (niche), notch
nill, null
nestle, nuzzle
noddle, noodle

prink, prank
pick, peck
pin, pen
piff, puff
pinch, punch
pick, pike
pleat, plait
peer, pore
peart, pert

quiver, quaver

riff, ruff
rash, rush
rimple, rumple
rag, rug
riffle, ruffle
reel, roll
rut, root
rest, roost
sprig, sprag
swig, swag
skimp, scamp
sprit, sprat
swish, swash
scribble, scrabble
snip, snap
sniff, snuff
spatter, sputter
straggle, struggle
skim, scum
splatter, splutter
stab, stub
spank, spunk
stamp, stump
sleek, slick
steer, stir
spree, spry
sheer, shore
squeal, squall
sheen, shine
sheave, shive
squeeze, squash
screech, scratch
squeak, squawk
scuff, scoff
spud, spade
sherd, shard

sled, slide
slack, slake
slim, slum
strut, straight
shirk, shark
share, shire
spike, spoke
scope, scoop
sock, soak
shave, shive
shy, shoo
scar, score
scroll, scrawl
stopple, staple

tight, taut
tray, trough
tress, truss
thrash, thrush
tatter, totter
tag, tug
tint, taint
tickle, tackle
tippet, tappet
tittle, tattle
trip, trap
tippler, toper
tipple, topple

wiggle, waggle
whit, what
whittle, wattle
wheel, wale
wreathe, writhe
wheeze, whiz
wail, waul
year, yore

These specimens, thus massed and presented to the linguistic consciousness of the English speaker, are, it is believed, sufficient to show that at least part of their significance is due to his association of their vocal sounds with the motion or mass, as well as the sounds, of the actions and objects named. The words exemplifying the fact have been classified according to their form because under such categories the speaker more easily appreciates a significance he gives a particular sound recurring in many words. Passing, now, from evidence of the fact to its explanation, we may reconsider the categories with regard to the means by which motion and mass, as well as sound, are imitated by vocal sounds.

The basis of the imitation in the first class, exemplified by the *l* of *jiggle*, the *r* of *jigger*, and the *rl* of *whirl*, is the peculiar movement of the tongue in the utterance of *r* and *l*. Other consonants are made with one position of the vocal organs, the sound being produced while the position is steadily maintained, as *s* or *th*, or upon the assuming or release of the position, as *k*, *m*, *d* or *p*. To produce *l* or *r*, however, the position of the vocal organs changes during the utterance, and, without this change, true *l* or *r* is not heard. The consonant begins and ends with a different position of the tongue. This characteristic of the particular means by which *l* or *r* is produced, this flap or change of position of the tongue, affords the speaker a simulation, while he utters these sounds, of repeated, quick or rotary motion. The simulation is not directly by sound, but by motion in making sound, and the sound thus made becomes associated with and imitative of motion.

The common characteristic of the other two classes, exemplified by *seesaw*, and *jiggle* compared with *joggle*, is contrast of sound associated with contrast of motion, direction or mass. The etymological basis of *seesaw* is the *sawing* motion. But the reciprocal action of *seesaw* is pictured, as it were, by the change from *e* to *aw*. The change from *i* to *a* in *zigzag* simulates the change of direction in the object the word names. In *namby-pamby* and *helter-skelter* the present significance of the words is due to the sense of diverse, contrasted, mixed motion, which is imitated by the alternation of *n* with *p* and *h* with *sk*.

In *seesaw* or *zigzag*, the contrast is apparent because it is in the one word. But in the specimens of the third list, the contrast is not so apparent because generally but one of the words compared is in conscious use at any given time. We seem to speak of *jiggling* without any reference to the fact that other things are *joggling*. Yet when these other things are *joggling*, we so describe them. Both words are in the linguistic storehouse of the speaker, and he chooses the appropriate one in any given case because there is a contrast between them, unconsciously appreciated, by which *jiggle* is associated with a quicker, lighter movement of an object than *joggle*. This contrast and association becomes apparent when our attention is called simultaneously to *jig*, *jog* or *flip*, *flop*.

This contrast, moreover, is already familiar to students of those languages which, in comparison with such as ours, may be called vocalic, such as Italian and Spanish, wherein the vowels are full and the consonants weak. The diminutive and augmentative additions to words in these languages, as Spanish *hombrecico* or *hombrecillo*, from *hombre*, compared with *hombrachon* or *hombronazo*, illustrate the play of this phonetic principle. The diminutive endings contain *i* (pronounced *ē* or *ĭ*) or *e* (pronounced *ĕ*) as *ica*, *ella*, *ela*, *zuela*, while the augmentative endings contain *o*, *a* and *a*, as *on*, *achon*, *azo*, *ote*. In English, however, the consonants and not the vowels form the distinctive characteristics of a word. They are more numerous and more forcibly uttered than in Spanish or Italian. Yet the arrangement of the present examples shows that even with us the correspondence of vowel and mass is active and potent in giving significance to our words. Our present attention, however, is directed to this as an element of English speech only, and therefore the argument is not aided here, as it might be, by illustrations from foreign tongues. That it exists in them is simply suggested by the foregoing reference to Spanish forms in order to show that what we here find in English is perhaps more apparent in other languages where the speaker dwells more strongly on vowels in uttering his words. So, too, the student of German will recall many forms collateral with the English examples of words with *r* and *l* illustrating repeated motion. But the extension of this principle to foreign languages is beyond the scope of this article.

We thus conclude from our examination of the specimens that there is an imitative association in the mind of the speaker, correlating —

(1) The flap of the tongue in producing *r* and *l*, with ideas of quick, repeated and rotatory motion;

(2) A change of vowel or consonant in repeated syllables of a word, otherwise alike, with reciprocal or opposing motion or direction, and

(3) The contracted or expanded contour of the mouth in producing the gamut of vowels from *ē* to *ō* and *oo*, with ideas respectively of small and large actions and things.

This association of the action in making sounds with the action of things the sounds name is, after all, but a form of gesture. Motions and positions of the hand, arm, face and head to imitate or emphasize the ideas of the speaker are universal and familiar. It is not *a priori* improbable, therefore, that the motions and positions of the vocal organs should ally themselves with ideas of motion and position in the objective world. The present array of specimens is intended as evidence of this proposition.

AT LONGPORT, NEW JERSEY, IN SEPTEMBER.*

BY GRACEANNA LEWIS.

A few years ago, in September, the writer had the opportunity of examining closely some animal forms which at this season of the year contribute to the luminosity of the sea along our eastern coast.

The night preceding and the night following the collection of the first material were noticeable for the phosphorescent light on the waves and also for the abundance of small masses of transparent jelly left upon the beach by the receding waters. A quantity of these jelly masses from the beach was placed in water dipped from the sea, in a large glass vessel, where it could be favorably seen. Very soon the organisms began to take shape and then to move in all directions with the greatest ease and apparent enjoyment. In form they were nearly circular, but as they presented different aspects, it was soon seen they were not globular. Viewed from above, below, or at either end, the outline was oval, the short diameter being not more than half the longer. Looking at the broad side, in a slight depression on the upper side might be seen a mouth opening into a gently expanded stomach, but not very well defined amid the surrounding jelly, all parts being so transparent that it was difficult to distinguish one from another. Beneath the stomach and connected with it by a slender passage, was a bulb from which proceeded four tubes, each dividing so as to present eight tubes in all. These curved in a funnel outwards and then upwards over the body, and again turned downwards, exchanging their contents in four chambers, two on each broad face of the body. As these chambers are connected with the circulation, I shall call them *circulatory chambers*, although they also perform an excretory function, eliminating from the nutritious food the waste material.

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* The Institute regrets it cannot reproduce the beautiful water color sketches accompanying this article. Their accuracy of outline and delicacy of color cannot be surpassed.

Overlying the circulatory tubes, and probably in immediate contact with them, are lines of minute bars, each furnished with cilia or hairs, in rapid and constant motion, breaking the light into all the prismatic colors — red, orange, yellow, green, blue and violet — with intermediate shades of the loveliest and most delicate hues imaginable. The bars are locomotive organs, and probably also serve respiratory purposes, since, as long as life lasts, their cilia never for a moment cease their activity.

Corresponding with the circulatory tubes, and also with the locomotive organs, are eight body lobes. Two on each side are prolonged into lappets which rise above the mouth and serve as fingers to aid in procuring food and in guiding it to the mouth. Around these lappets the circulatory tubes extend up one side and down the other, then descending into the circulatory chamber, the motion of the fluid being beautifully seen, with a tremulous, half pulsatory throbbing within the chamber, where they meet the tubes from the exterior lobes. The two exterior lobes on each side are conjoined so as to form a rounded mass, but little above the line of the mouth, and from them circulatory tubes are sent downward into the circulatory chamber to meet and exchange their fluid with that coming from the middle lobes and their lappets. It will, therefore, at once be understood that these apparently helpless masses of jelly, picked up from the sand of the beach, or dipped from the sea, are in reality highly organized beings, possessing muscles, possibly nerves, and assuredly a circulatory apparatus of extraordinary perfection.

The group to which they belong is known as the *Ctenophora*, or Comb Bearers, so termed on account of the comb-like appearance of their locomotive organs, in which the bars present a somewhat fanciful likeness to the head of a comb, and the hairs or cilia to the teeth.

Agassiz, who studied these animals minutely, regarded them as an Order somewhat related to the Corals, but most nearly allied to the Hydroids or Jelly Fishes, but higher in organization than either.

Agassiz divided the *Ctenophora* into three sub-orders, all of which are represented on our Atlantic coast.

The first sub-order is that of the *Beroidae*.

The second sub-order is that of the *Saccatae*, to which, along with many others, the well known genus *Pleurobrachia* belongs. No members of this group were observed at Longport, and none of the *Saccatae*.

The third sub-order is the *Lobatae*, in which the body is composed of lobes corresponding in number with the circulatory tubes and with the lines of locomotive appendages, all the members being furnished with lappets on either side of a small mouth.

Here, then, belonged the objects before us. But the sub-order of the *Lobatae* includes a number of families, each with its own genera and species. To which were these related? Were they resident at Longport, or had they been driven hither by storm currents? Five years before, much earlier in the season, the writer had seen the very same objects abundant in the Thoroughfare between Longport and the mainland, and also in the waters of Great Egg Harbor. They were observed for days and could scarcely be mistaken. Clearly the only way to decide was to make careful water color paintings and compare them with the illustrations already published, in addition to close observations on the structure, habits and motions of this species. It was soon found that the problem was complicated, if rendered more interesting, by finding more than one species to deal with, and also by observing that new species were brought in from day to day.

In the species recognized as that seen at Longport five years before, the lobes were exceedingly transparent — the colors of the cilia, whilst very beautiful, were so delicate as to remind one of the tints in auroral flashes; the circulatory chambers were not very deep, not much over half the depth of the body; the lappets were not very large, and the conjoined, external lobes did not rise much above the mouth line. It was a symmetrical as well as transparent species. Once seen, it could ever after be readily recognized.

Whilst this species was under my observation, I had removed a large and active individual by dipping it up with a tumbler to bring it nearer to my eye. Along with it was a small and disintegrating one, which happened to be taken up also, and upon this specimen my attention was concentrated. At the end of one of its broken and dissolving lines of flappers appeared a spiral of motion, continuing for half an hour or more, when it broke away and floated off, apparently a complete organism, rotating on its own axis in a horizontal direction and keeping up its constant, ciliary motion. Very soon a second spiral, *without cilia*, floated off, and like the other, apparently began an independent existence, but instead of rotating on its own axis in a horizontal, it revolved in a vertical direction, and was nearly twice as large as the ciliated body. In this smooth, plate-like spiral there were two white specks, symmetrically placed one above, the other below the point of union or umbone of the spiral. Of course I cannot assert that these white specks were nerve masses. I can only say they looked like it, and suggest further inquiry. It may be conjectured that these spirals, which looked and behaved like independent beings, were merely parts of a dissolving animal still retaining motile power. Parts which break off do frequently present that phenomenon. But other spirals, several in number, succeeded these already mentioned, and from their appearance I am strongly inclined to believe this an instance of genuine fissaporous multiplication, and that the young in this species may be evolved from the same tracts which in other species give rise to eggs.

My attention was partly diverted from these extremely interesting objects by discovering that the large individual in the tumbler intended to feed on the smaller and dissolving one, or possibly on the young fry. Mouth downward, and with eager motions, it bent its energies to that purpose. It expanded its exterior lobes and flattened them over the jelly mass, gathering together in the manner of fingers all four of its lappets, the better to grasp its food. Backing off as far as the dimensions of the tumbler permitted, it returned again and again to the charge, evidently hampered for want of "sea room," in the curve of the tumbler where the jelly mass lay. Finally it did envelop one of my little ciliated friends and caught it in its embrace, but whether the morsel entered its mouth or not I failed to see. The whole of the jelly mass, which seemed to be the object of attack, looked to me to be too large for the small mouth and the almost linear stomach. How much both could be distended I am not prepared to say, since I did not see the food enter. I can only assert that from its behavior the attacking animal was evidently hungry, and earnestly seeking food to the best of its ability under unnatural conditions.

This species answers to the description of *Bolina vitrea*, which Agassiz found only at Key West, Florida. Either there are two very similar species, one with a northern and the other a southern habitat, or else the one species was brought as far north as Longport by storm currents, a supposition which would not agree with the fact of the same species having been seen much earlier in the season and in great abundance in the bay waters of Longport at a previous time.

Whilst examining these *Bolinas*, another species in company with them attracted my attention as presenting interesting differences. This was larger, pear-shaped instead of rounded, and was further distinguished by small elevations or papillæ upon its surface, and by the strong and very distinct and rich coloring of the cilia. It lived seventy-eight hours after being brought in from the sea. This I supposed to be an *Eucharis* of the family *Mnemiidae*, a southern species brought hither by storms.

The next time my collection of material was examined, there were found no specimens similar to the preceding. The majority of this second collection were undoubtedly *Bolina alata*, a species found in the waters on the coast of Massachusetts, and northward to Maine and Labrador. In this species the external lobes are greatly inflated, the lappets are much larger, the circulatory chambers much deeper, the color of the cilia more vivid than in *Bolina vitrea*. Altogether it is a far more robust species. Of American *Bolinas*, another species belongs to Behring's Straits and still another to the North Pacific Ocean.

Amongst these winged *Bolinas* there was one specimen wholly different from any seen before. The lobes were not inflated, but conical, and the lappets were very short, not reaching beyond the level of the mouth, and of course wholly useless in the catching of prey. The circulatory chambers in this species were remarkably deep. This was probably a member of the genus *Eurampheaea*, of the family *Eurampheaidae*, a tropical representative of the sub-order *Lobatae*.

Another morning a collection was made at the bayside instead of the ocean beach, and there were brought in no specimens of the sub-order *Lobatae*, but a number of *Idya roseola*, belonging to the sub-order *Beroidae*.

Idya roseola, which was named by Professor Agassiz in 1858, in that year appeared in great numbers along the whole coast of Massachusetts, tingeing the sea in patches with its delicate roseate hue during the whole summer. They laid their eggs, and the young hatched from them were seen by Alexander Agassiz from the beginning of August to the first week in September.

In his account of these he says: —

"After the spawning season the parent *Idyas* grew paler and paler, and the first storms of September broke them all to pieces and nothing could be found afterward but broken fragments." I remained at Longport until the close of September. These living *Idyas* were found on some of the later days of my visit, and had escaped the fate which awaited them, although many severe storms had intervened between that time and their spawning season.

Of their beauty when in their prime Agassiz says: — "There is hardly anything among Acalephs equal to the beauty of the iridescence of the locomotive flappers of our *Idya*, playing with all the colors of the rainbow between the rosy edges of its ambulacral zones." This description is partially true even of the specimens found so late in the season at Longport. Although the body wall was changed in color and reduced in thickness to about a quarter, instead of a whole inch, the cilia could have been imitated only with material giving the richest of colors in pearly effects.

If one were to imagine a thumbless mitten large enough for the hand of a child of seven or eight years of age, it would give a good idea of the form and size of these *Idyas*. In the *Lobatae* the mouth is small. In the *Beroidae*, on the contrary, the whole end of the bag or pouch forming the body is an open mouth, and this is so extensile that Agassiz assures us he has seen an *Idya* swallow a *Bolina alata* larger than itself.

Of the thirteen specimens brought in at Longport, none took food, possibly because there was nothing in the vessel for them to eat, and only one was sufficiently active to exhibit conspicuous changes of form. This exceptionally lively one would at times draw in its body and expand its mouth until it became urn-shaped, and again turn its mouth inward and close the opening until it assumed the form of a ball, between three and four inches in diameter. It is quite possible that it was suffering from hunger, as Agassiz describes *Idya roseola* as a greedy animal, eating freely of *Bolinas* and *Pleurobrachia* when all three were in the same vessel together. Not remembering its tastes, we could not at the time supply its needs.

These *Idyas*, and all the other species of *Ctenophora* in our possession, were highly phosphorescent, and when the glass vessel containing them was shaken, or the water stirred, they emitted their splendid white light to the admiration of all beholders.

On the morning of the 29th of September the ocean beach was again thickly strewn with masses of jelly, which proved on examination to be what for convenience, and until better informed, I shall continue to designate as *Bolina vitrea*, the same species found on first arrival. After keeping them in the large, glass vessel, and watching them during the day, I took a few in a tumbler to my chamber, and every time I wakened during the night and stirred the water, it became glowing with phosphorescence.

From the intense light emitted by the few we had in our possession, it is easy to imagine the effect of the tossing waves filled with swarms of these tiny creatures. They do, in fact, cause long lines of light on the breakers, and on the beach whenever the sand is scraped by a passing foot, so as to leave a pathway of illumination. Many other inhabitants of the sea are phosphorescent, but of these we do not speak at present. Each kind has its own season, and for *Ctenophora* the season of observation was the happy month of September.

From what has been said, it is plain that both northern and southern forms meet at Longport, especially after the mingling of northern and southern currents in great storms. It is also clear that at such seasons much may be lost to natural history for want of trained observers. The most unexpected results might reward organized effort on the part of scientists along the whole coast of America, both Atlantic and Pacific, at different seasons of the year.

THE MENTALITY OF THE HORSE.

BY B. M. UNDERHILL, V. M. D.

So far as our present data enable us to judge, the most intelligent animals are not necessarily those nearest to man in the systems of zoological classification. In a branch of the Animal Kingdom we may find groups with mental endowments considerably above those of some members of a branch higher in the zoological scale, as, for instance, some insect members of the Arthropoda when compared in this respect with the lowest Vertebrates. Psychical evolution is not continuous with organic evolution, and groups within groups show such breaks. Thus, mental development is not continuous with the ascending series of orders in the class Mammalia. Descending from the highest intelligence, the mammalian orders containing species that manifest intelligence in notable degree have been listed as follows: — 1, Primates (including man); 2, Carnivora (dog); 3, Proboscidia (elephant); 4, Ungulata (horse); 5, Rodentia (beaver). Taking a classification in descending order zoologically we have: — 1, Primates; 2, Insectivora; 3, Cheiroptera; 4, Rodentia; 5, Carnivora; 6, Proboscidia; 7, Ungulata; 8, Cetacea; 9, Sirenia; 10, Edentata; 11, Marsupialia; 12, Monotremata. The last five in this list (whale, manatee, sloth, kangaroo, duck-mole) are not remarkable for their intelligence. In the fifth, sixth and seventh (dog, elephant, horse) intelligence follows the zoological orders in descending degree; the fourth (beaver) ranks above all these zoologically, but beneath them psychologically, while the second and third (moles, shrews, bats) are placed above all animals in the zoological scale except Primates, yet they are not worthy of mention in a list distinguished for intelligence.

As will be seen in the order given, the intelligence of the horse is exceeded by that of the dog and elephant. He must also give way in this respect to that humble member of his own family, the ass, but compared in intelligence with the other Ungulates, such as the stupid, staring ox, he seems to stand well above them all.

Throughout history the horse has been exalted as man's fittest companion in peace and war. His proud carriage, stamina, lines of beauty, and big, gentle eyes appeal to us, and we like to regard him as the most intelligent of our animals. The writer has had but comparatively little opportunity to observe the mental operations of the lower animals other than those in domestication, and it is perhaps unnecessary to say that he is neither a psychologist nor an experimental investigator in the subject. Such observations as he has made, however, during a considerable experience with the horse, are not in support of the mental rating to which we who are his admirers are inclined to assign him. Perhaps we are most often misled in our conclusions as to animal mentality by too readily inferring the existence of thoughts and emotions similar to our own from actions which appear to exhibit them. The contemplation of the workings of the mind in animals lower than ourselves seems simple enough when I consider the activities due to the operations of my own mind and then, by analogy, infer mental operations from the observed activities in them. Thus, a friend appears, coming to greet me, and, through regard for him as a friend, I give expression to my pleasure by an exclamation. I approach my horse; he regards me intently, and as I draw near he gives a low whinny. Reasoning from the activity which my own feeling for a friend prompts, I conclude that the horse looks upon me as a friend and that this is his way of expressing his pleasure at my approach. Again, I wish to enter a man's house and, presuming he is in and will come to open the door if I make my presence known, I knock. Similarly, my dog comes to my door and paws at it, manifesting a desire to get in. Reasoning by analogy, I conclude that he paws the door to tell me that he is there and that he wants me to open it for him. And so, numerous examples might be cited of the application of this method, which assumes that certain observable activities in lower animals, similar to certain activities in ourselves; are the result of the same mental or emotional promptings.

But why should the whinny of the horse at my approach signify his regard for me personally? Granting it to be an expression of pleasure, it is quite likely from a very different source than my pleasure at the approach of a friend. The horse's principal pleasure is in eating, the gratification of which he associates with my approach. Again, in the case of my dog, his purpose in scratching at my door cannot necessarily be to make me aware that he is there, and a summons for me to come and open it, for the dog will give this same manifestation of a desire to enter a strange building containing perhaps a choice morsel of meat, or another dog whose company he desires.

In the horse, action has a strong impelling power in habit. I repeatedly turn my horse to a watering trough along the roadside and he as often refreshes himself with a good drink. Again as we approach the trough, I slack the reins, that is, "give him his head," and he turns to the trough of his own volition, as I would turn to a well if thirsty. But this time he does not drink, but merely noses around in an idle sort of way, or, in a rather ludicrous manner, seems to express an inquiry of me as to what he shall do next. Here we have an action, not coördinating with the idea of quenching thirst, as a similar action of ours would be, but impelled by habit purely. The presence of thirst has no influence for, and the absence of thirst has no influence against the action in this case.

All who drive have frequent demonstrations of the influence of habit upon the actions of a horse, how he will unexpectedly turn toward certain roads, lanes, stables, and other places into which he may have been driven a month or more before. I take my horse to the same blacksmith shop regularly once a month, and he is shod always by the same smith. One day he breaks out of his stable and, making a frolic of his freedom, trots off down the road. Somewhat puzzled by his new experience, and perhaps a little apprehensive of danger, he approaches the familiar shop of the smith, and habit, as well as confidence that he has nothing to fear there, leads him to turn in. The smith approaches him in a kindly way, and, as is his usual habit in this place when this man passes his hand over his shoulder, the horse lifts his foot. It would be surprising if the smith did not then perceive a nail that needed tightening, or possibly a loose shoe, and he proceeds to fix everything right. Then along comes the anecdote of the wise horse that went to the blacksmith's of his own accord and lifted his foot to be shod, reported from the observation of the "gentleman of undoubted integrity." Facts true enough, but misinterpreted.

The question as to whether horses, or any of the lower animals for that matter, reason, is one that will perhaps not admit of solution, in the light of our present knowledge at least. The writer has never felt justified in holding the opinion that they do not, in the absence of proof that certain actions in these animals, generally considered as instinctive, are not fundamentally referable to reason. Special acts of ratiocination occurring in creatures placed amid surroundings that daily required them, would eventually become habitual and instinctive. As habit and instinct are transmissible to progeny, these actions might be observable in succeeding generations, even though the conditions that required them to be frequently repeated as original acts of reason are no longer present. If an act of instinct has its origin in ancestral acts of ratiocination, why should there not be other acts of ratiocination in the present generation?

Weir defines reason as "the intelligent correlation of ideation and action for definite purposes not instinctive." It might seem, then, that when my horse lifts the latch of his stall door, pushes the door open with his nose and walks out, as he has often been seen to do, he reasons, for, granting that we have here the idea to leave the stall, we also appear to have a correlated action for the definite purpose of opening the door. But it seems we are confronted with a difficulty, for when this was first done there was no idea preëxisting the action, and the action was for no definite purpose, and of course was not instinctive in this case; he happened to lift the latch as he was nosing about after a morsel of feed, and the door was pushed open by the movements of his lips, but he manifested no desire to come out until I encouraged him to do so. There seems to be a very close association of events in the memory of the horse, and probably on subsequent occasions the memory of the flipping up of the latch was associated with the accomplishment of an idea to leave the stall, with no knowledge of the relation of the lifting of the latch to means of attaining this end. When I remove the latch and place a sliding bar on the door, purposely made much easier for him to manipulate, it never occurs to him to take such action, though I move it back and open the door in his presence numerous times.

It is by the analysis of such little commonplace occurrences as these going on about us every day, that we can best study the mental operations of these animals and judge for ourselves as to whether they do or do not reason. In this contemplation we may well leave out of consideration the astonishing performances of trick animals, such as performing elephants, "educated horses," etc. On the same stage upon which we see these mathematical and patriotic horses perform, we also see men pick coins from the air, and cause rabbits to jump out of silk hats; all deception of no scientific interest except as an instance of clever training.

The special development for flight in the horse is a protective one coördinating with his emotion of fear. The little, four-toed ancestor of the horse had little to fear from the Carnivora contemporary with him in that far-off beginning of the Age of Mammals, but as beasts of prey became more formidable and the character of the land surface changed, the ancestral horses developed anatomical characters adapting them to greater speed, and this evolution toward adaptation to flight has given us the most remarkable instance of special development that we have in the Animal Kingdom. With this development of flight we have a corresponding development of the emotion which impels it — fear, which emotional feature in the horse has become so predominating as to at times overwhelm every other mental faculty in one mad impulse to run, in which insane terror he will dash with terrific speed into a stone wall or river with the possession of every other sense lost. A bit of paper moved about by the air currents, or the report of a gun, may bring the impulse which, if yielded to and survived, leaves the animal in such an acute state of apprehensiveness that it is apt to be soon repeated from even less cause. This impulse to unreasoning flight following sudden fear is observed not only in animals inferior to the horse in intelligence, but in man himself. In the former we have an instance of it in the stampede of the cattle herd, and in the latter, the panic of the theatre audience, from causes as trifling, perhaps, as that of the bit of moving paper, but which if yielded to becomes cumulative and quenches every human attribute of sense and reason. In these cases the exciting cause of the impulse is largely example, the manifestations of fear in some exciting it in others until the entire herd or audience, as may be, is dominated by it. The horse is also thus affected by manifestations of fright in others and he will stampede in mass as will cattle and men, but he does not need the suggestion from those about him. The individual will as quickly launch into the crazy runaway, and without an instant's hesitation to investigate the degree of danger. It is the one trait that has preserved his species and brought him safely through to the Dawn of History and man's protection.

Some accounts that we have of the martial emotions of horses in war, such as "scenting the battle," "eagerness for the fray," and "neighing with fury against the enemy," are picturesque, but are probably founded upon certain manifestations peculiar to the horse, apt to be misinterpreted even by horsemen, not close observers. Probably the sensations of a horse in battle were expressed by General Sheridan, who, when asked whether he was not scared when in the thick of the fight, is said to have replied: "Scared! Scared! Of course, I was scared — scared as h——, but I couldn't get away. It was my business to stay right there and fight." If Sheridan couldn't get away it was because he was held there by his sense of duty and patriotism. If his horse didn't get away it was because he was held there by the hand of his rider. In the face of a danger which he understands, where he can measure his aggressiveness, so to speak, with that of an opponent, the impulse to flight does not assert itself: here he displays courage, and will put up a ferocious fight, as in the battle for the harem, the mare in defense of her foal, or in contest with an attacking carnivorous animal, where heels are used as weapons instead of flight.

While certain activities in lower animals may be prompted by mental states differing from those which actuate similar manifestations in ourselves, yet the best conception that we can form of them must be arrived at by such a comparison, for our own mental states are the only ones of which we have actual knowledge. But we should avoid a too ready inference from these premises, as well as a sceptical demand for evidence that is impossible. There are mental qualities of animals of which we can speak more exactly. That the horse, as our example, is susceptible to considerable education is a matter of such common demonstration as to be little noticed; let him pass through one generation in his native environment and he reverts to wildness, but in association with man he becomes, while yet impetuous, trustful, forbearing, quick to perceive man's intentions and ready to lend his powers, clean, docile, and altogether an agreeable associate. That he may in some degree possess those mental and emotional attributes which we know are human, may be admitted, but we must also admit that actions which appear to denote them may be deceptive. We need go no higher than the insects to find actions which appear to denote mental operations and emotions similar to our own. If we suppose that they have such mentality and that they feel these emotions as we do, then we are forced to the conclusion that the development of such phenomena is not correlative with organic evolution, and that they are not dependent upon the agency of a highly specialized organ.

NATURAL SOURCES OF POLARIZED LIGHT.

BY C. M. BROOMALL.

Few people realize what a common phenomenon polarized light is in nature. Indeed, as regards reflected light, it may be said that unpolarized rays are the exception rather than the rule. In this connection the following simple experiments concerning facts familiar to every student of physics may be of sufficient general interest to mention.

On the occasion of a recent quite vivid rainbow display, the writer was afforded a particularly good opportunity, with very simple apparatus, to demonstrate the fact that the light from the rainbow is polarized. It was found by experimenting with a Nichol prism held in the hand between the eye and the rainbow that all the colors of the spectrum were strongly polarized. When the prism was held in one certain position the rainbow would be plainly visible, while when the Nichol was rotated ninety degrees the colors disappeared. It impressed one as almost magical to see this great band of color completely obliterated by the simple rotation of a transparent body. A piece of mica, which happened to be handy, was then interposed between the Nichol and the rainbow, and it was found that, when the mica was held at the proper angle, it had the power to bring back again into view the rainbow previously made invisible by the prism. If the Nichol was now rotated ninety degrees, all portions of the rainbow became visible again, except the portion shielded by the piece of mica. In other words, the mica, if properly oriented, made the rainbow invisible to the eye when the Nichol was in such a position as to allow the colors to be clearly seen, while when the prism was in such a position as to hide the bow the mica brought it plainly into view. It was a very interesting sight to view the leaden sky through the prism and then restore the beautiful colors of the rainbow by the interposition of a piece of ordinary mica. As was to be expected, the thickness of the mica was of considerable importance, as certain portions of it were found to possess the shielding action referred to in much greater degree than others. With a stronger light than actually exists in the rainbow the shielding action would not be so complete, as theoretically one thickness of mica could only cause complete extinction for one particular color.

On this occasion, although the primary bow was unusually bright, the secondary rainbow was scarcely visible, so that it was not possible to make use of the light from this source.

As is well known, the primary bow is the result of two refractions and one reflection in the rain-drops. The phenomenon in this case gives, therefore, an interesting example of the production of a spectrum by refraction and the polarization of the light by reflection.

In another experiment, a piece of Iceland spar, about an inch and a half long and half an inch through, was the source of both spectrum and polarization. This piece of calcite, while quite clear, had become somewhat shattered by rough usage and when looked at in certain directions exhibited brightly colored, thin-film spectra. The planes producing these colors were not parallel with the faces of the rhombohedron, but were at all sorts of angles. The colors were visible upon viewing the crystal from several different directions and in every case were found to exhibit polarization. A Nichol prism held in the hand in one position would allow the colors to be seen in all their brightness, while when the prism was rotated ninety degrees all light disappeared. An analysis of the paths of the light rays in this experiment would be difficult and would no doubt show the action to be different for different positions of the crystal. When the light first enters the calcite it probably suffers the usual polarization and is divided into the ordinary and extraordinary rays vibrating at right angles to each other. What would happen to these rays at the surfaces of the minute cracks is problematical. Among other actions there might be unequal reflection of the two rays, or there might be recombination and color-effects by extinction: again, there might be the independent production of polarized light due to reflection alone. In any case, however, after the reflection at the thin-films, interference and the appearance of thin-film colors would result in the usual way. And, finally, these colored rays in passing through the crystal after reflection might be further changed. It is evident, therefore, that an exact analysis of the action in detail is out of the question here. Perhaps the best we can do is to attribute most of the polarization to the polarizing property of the spar and the spectral colors in the main to the interference after reflection at the thin-films.

Again, a natural source of polarized light not familiar to everyone is to be found in the light of the sky viewed at right angles to the rays of the sun. Thus, if the southern sky be looked at through a Nichol prism toward the hour of sunset, the light will be found polarized and will exhibit alternate light and darkness as the analyser is rotated. A piece of ordinary mica held up against the sky and viewed through the Nichol will then exhibit most beautiful colors as it is moved about before the eye.

The same kind of polarization can be seen by moonlight. If, on a brightly moonlit night, the sky is examined with a Nichol prism in a direction at right angles to the moon's rays, the light will be found very perceptibly polarized. An interposed piece of mica will show alternately light on a dark field and dark on a light field, as the prism is rotated. The contrasts of light and dark are quite strong, but the light is not sufficiently intense to show color. If the sky is looked at in the direction of the moon no polarization is visible. Although the moonlight is produced by reflection, it is not the kind of reflection, nor at the proper angle, to produce much polarized light.

It is needless to say many other natural sources of polarized light occurring around us might be mentioned. The examples cited, however, may serve the purpose of the writer and interest some new disciple in this interesting field of study.

MINUTES OF MEETINGS.

FEBRUARY 4, 1909. — Regular monthly meeting, with the President, T. Chalkley Palmer, in the chair. Reports of Committees, Curators and Officers. The following additions to the Library were announced: "The Reptile Book;" "Bulletin 34, U. S. Geological Survey;" "Bulletin 339, U. S. Geological Survey;" "Annual Report of the Smithsonian Institution for 1907;" "Annual Report of the Bureau of Ethnology, 1904-1905;" "Bulletin 34, Bureau of American Ethnology." Under the head of scientific business, Albert S. Barker exhibited under the microscope a specimen of *Chelifer cancroides*, one of the False Scorpions of the class Pedipalpi, a class including also the true scorpions and placed by Packard and others among the spiders. According to Packard the Chelifer inhabits dusty places and books, living on mites, etc., but it has recently been reported as a parasite on poultry. Mr. Barker also exhibited a microscopic preparation of the prothallium of a fern, showing the development of the first root and first frond from the germ cell on the lower surface of the prothallium. C. M. Broomall presented a collection of pearls from the common oyster. Sanford Omensetter exhibited a dead specimen of the Star-nosed Mole (*Condylura cristata*), captured at Rose Valley and submitted for identification. President T. Chalkley Palmer spoke of the venerable theory that extremely old seeds could be made to germinate. He said that recent experiments had demonstrated the contrary as to this, which would preclude the possibility of germination in such seeds as the so-called "mummy seeds." Dr. Horace H. Furness, of Wallingford, Pa., presented to the Institute a collection of thirty specimens of Phanerogams from the Island of St. Croix. Meeting adjourned.

FEBRUARY 11, 1909.—Adjourned meeting. Lecture, "The Physical Basis of Music," by Harold C. Barker, A. M., Ph. D., instructor in physics, University of Pennsylvania. The subject was illustrated by apparatus and lantern slides.

FEBRUARY 18, 1909. — Adjourned meeting. Lecture, "A New English Poet," by Prof. Wilkie Nelson Collins, of the University of Pennsylvania.

FEBRUARY 25, 1909.—Adjourned meeting. Lecture, "The Study of Language," by Henry L. Broomall.

MARCH 4, 1909. — Regular monthly meeting, with the President, T. Chalkley Palmer, in the chair. Reports of Curators and Committees and current business. Under scientific communications C. M. Broomall presented a specimen of pyrites in calcite from French Creek, Chester County, Pa. A discussion followed concerning the pronunciation of the word pyrites. It was shown that either "py-ri′-tes" or "py′-rites" was correct. Albert S. Barker exhibited a specimen of *Myxomycetes*, or Slime Mould, and gave an interesting talk upon its life history. Dr. B. M. Underhill presented to the Institute a collection of "hardware" taken from the stomach of a six year old cow. The assortment comprised some twenty-four pieces of wire, screws, iron nails, etc. One of the pieces had caused the death of the animal by penetrating the walls of the stomach and entering the heart. C. M. Broomall spoke of the disappearance of marks made by surveyors' chalk on fresh wood. The explanation was offered that it might be caused by the presence of tannic acid in the wood. The President exhibited a new English binocular microscope, and explained its points of difference from other makes. Meeting adjourned.

MARCH 11, 1909. — Adjourned meeting. Illustrated lecture, "The Yellowstone National Park," by Dr. E. D. Fitch.

MARCH 18, 1909. — Adjourned meeting. Lecture, "The White Corpuscle," by Ralph L. Johnson, M. A.

MARCH 25, 1909. — Adjourned meeting. Illustrated lecture, "The Land of Dykes and Windmills," Dr. E. D. Fitch.

APRIL 1, 1909.—Regular business meeting, with the President, T. Chalkley Palmer, in the chair. Reports of Curators, Committees and Officers. The regular nomination of officers was held, and the following were named : —

President, T. Chalkley Palmer
First Vice President, Henry L. Broomall
Second Vice President, Charles Potts
Secretary, B. M. Underhill, V. M. D.
Treasurer, Carolus M. Broomall
Librarian, Henrietta K. Broomall
Board of Curators,
Edgar T. Miller, Homer E. Hoopes and
the Officers

On motion it was agreed that the Publication Committee be given the power to add two more members to its body, selected from the membership of the Institute. "Descriptive Mineralogy," by Dana and Brush, and "Familiar Quotations," by Bartlett, which had been in bad condition, were reported rebound and again available for reference. The following additions to the Library were announced : — "The Guadalupian Fauna," by Girtz ; "Topographic Maps," by Salisbury and Atwood. A committee was appointed to amend the article of the Constitution relating to membership and to consider the creation of a grade of membership to be known as "Fellowship." Under scientific communications C. Edgar Ogden exhibited some specimens from a shell mound at Tampa Bay, Florida, consisting of flints in chalk formation and silicified coral. Mr. Ogden also exhibited a specimen of mistletoe, which he had found growing upon an oak tree, which latter was apparently dying from the effects of the parasite. Albert S. Barker showed, under the microscope, some marl from Jamaica, also some *Spirogyra* in conjugation. He called attention to the general statement in books that conjugation takes place only in the Spring, and then only in those filaments of a brown or yellow color. The filaments here shown, however, were green, and had been gathered in September. Meeting adjourned.

APRIL 8, 1909. — Adjourned meeting. Lecture, "Bird Migrations," by Prof. Charles W. Palmer, of the Westtown Boarding School.

APRIL 15, 1909.—Adjourned meeting. Lecture, "Electromagnetic Induction," by Harold C. Barker, A. M., Ph. D., instructor in physics, University of Pennsylvania. The lecture was illustrated by the Tesla oscillator and other electrical apparatus.

MINUTES OF SECTION A.

APRIL 22, 1909. — A meeting to consider the formation of a Section devoted to the investigation and discussion of the sciences convened in the hall of the Institute on the above date. Albert S. Barker was nominated for Director and Sanford Omensetter for Recorder, and they were unanimously elected to those positions. Dr. B. M. Underhill reported that he had so far been unable to determine the species of insect found parasitic upon the body of a mole (*Scalops aquaticus*), captured in Media Cemetery. The Doctor exhibited specimens of the long nosed ox louse (*Hematopinus vituli*), procured from a cow. The usual habitat of this species is upon calves. He also showed a specimen of *Filaria immitis*, a thread-like worm infesting the right ventricle and pulmonary artery of a dog, and was first described by Prof. Leidy. C. M. Broomall presented milk apparently colonized by a red mould, most likely in the mycelium stage. He was requested to preserve some and await developments. The following question was referred to T. Chalkley Palmer: "What is the reaction between formaldehyde and potassium permanganate?" Albert S. Barker showed *Closterium* (a desmid) in conjugation, with twin spores, collected April 17th last in a marshy spot near Broomall's Run. Also *Vaucheria*, with sexual organs, collected same date and place. A specimen of the fresh water species, *Hydra viridis*, excited much interest. Section adjourned.

APRIL 29, 1909. — The Section convened with the Director, Albert S. Barker, in the chair. The minutes of the last meeting were read and approved. The question of rules and method of obtaining membership in the Section were spoken of, but no action was taken, except that those present seemed to advocate meetings of an entirely informal nature. C. M. Broomall read from "Waves and Ripples" (J. A. Fleming, London) an account of the eruption of the volcano Krakatoa on August 27th, 1883. In this cataclysm the top of the mountain was blown off, and by the aid of delicate instruments it was proved that the resultant sound waves circled the earth seven times. General discussion on sound, its nature and definition, ensued. Dr. E. D. Fitch mentioned that when viewing an object microscopically it was possible on a contiguous piece of paper to see an image sufficiently clear to draw with a pencil. He asked an explanation, which was given by Albert S. Barker. Dr. B. M. Underhill exhibited specimens of the ox louse (*Trichodectes scalaris*), a species found upon cattle, and of biting and climbing habit. These had been mounted by the Director upon slides for the microscope. Following the subject of parasites, Charles Potts spoke of finding a spider's nest which had been inhabited by some thirty specimens of ichneumon, and Sanford Omensetter produced a chrysalis of *Samia cecropia* almost totally cleared of its interior by some parasite, also probably ichneumon. Sanford Omensetter gave his observations on the actions of the common earthworm (*Lumbricus terrestris*) in its attempts to uproot and store in its burrows freshly planted onion sets. Charles Potts had noticed the same proclivities. Albert S. Barker exhibited *Spirogyra* in early and complete stages of conjugation, also specimens of *Amoeba* (*radiosa*?). The Section adjourned.

INSTITUTE NOTES.

Since the last issue of the PROCEEDINGS there has been organized a Section of workers for the Summer months under the title of "Section A." Heretofore it has been the custom of the Institute during the Summer to meet only once a month. There is, however, so much of scientific interest occurring during that season of the year, especially as regards biological subjects, that the organization of such a Section to carry on weekly meetings was a happy thought. The first intention was to limit its field of activity to biology and kindred subjects, but such wide interest has been taken in the meetings that the Section is now open to all branches of science.

The year 1909 is remarkable for the warm weather that occurred during the month of February. During that month in this locality maple trees were in bud, the crow blackbird was observed as early as February 10th, and a large flock of robins as early as February 24th. The latter species may be found in sheltered situations in this locality throughout the colder months, but not in flocks.

In the PROCEEDINGS of October, 1908, reference was made to a fossil tree stump to be seen on the grounds of the old Shortlidge Academy, Media. This stump had been brought down from the coal regions of Pennsylvania about the year 1886. The Institute has been fortunate enough to obtain possession of the fossil and it now occupies a post of honor on the lawn of the Institute Building.

A live specimen of the small brown bat (*Vespertilio subulatus*), recently captured by a member of the Institute, has offered an opportunity for some interesting observations. One noticeable characteristic about the animal was the peculiar, stale odor which accompanied it. Another equally unpleasant characteristic was the fact, disclosed by an examination of its fur, that it was quite numerously populated by a species of louse. The respiration of the animal was plainly visible, and the average number of counts, when the animal was in a state of repose, gave as a result 160 respirations per minute. Naturally, the respiration suggested the taking of the animal's pulse. This at first seemed difficult to do, but the problem was solved when one of the members bethought himself of a stethoscope that happened to be available. This was one of the "telephonic" type of instrument, the diaphragm being connected with the ears of the experimenter by two rubber tubes. The bat was placed in a Mason jar, over the mouth of which was tied a paper cover. The jar was now inverted and placed upon the diaphragm of the stethoscope, so that there was nothing between the bat and the instrument except a thin layer of paper. The heart beat of the little creature was now plainly heard, but was far too rapid to be counted. In order to estimate the number of beats it was necessary to catch the rhythm of the heart beat by tapping alternately with the two hands upon the table, counting the taps of one hand only, and doubling. This gave as the result an average of 448 heart beats per minute. This is approximately three times the number of respirations per minute. The rate of respiration and heart beat was very much influenced by the nervous condition of the creature. Before each trial it was necessary to wait some little time, with everything quiet, until the frightened animal became composed.

The Publication Committee has recently had added to it two new members, namely, Charles Potts and Dr. B. M. Underhill. These appointments were made to fill the vacancies caused by the deaths of Jacob B. Brown and Dr. Linnæus Fussell.

At a recent meeting of the Board of Curators a resolution was passed directing that the Institute Building be painted this year. This is something that has been needed a long time.

Through the kindness of President T. Chalkley Palmer and Secretary B. M. Underhill the Institute has been given the use, for an indefinite period, of a pair of microscopes. These, together with the instruments already owned by the Institute, make a very suitable equipment. The Institute has also at its disposal a neat little chemical laboratory, with a full set of reagents.

Among the recent acquisitions to the Museum is a section of an old wooden water pipe dug up in the streets of Philadelphia in 1909. This pipe was laid in the year 1800, and despite a century under ground is in a good state of preservation. The bark is still intact in some places and the wood shows few of the signs of decay. The section of pipe is about a foot in diameter, with a hole some five inches in diameter through the middle.

The Library of the Institute has recently had added to it several good works on microscopy, biology and zoology. The activity of the recently organized Section A has made these purchases necessary. There is no standing Library Committee, but it is always the policy of the Institute to purchase a desirable work when any member requests it.

As an illustration of the amount of work required in the preparation of a paper upon a scientific subject, the first article in this number of the PROCEEDINGS is a good example. To collect the data for such a subject it was necessary for the author to read through the Century Dictionary.

The lecture course for the past year has been a very successful one. A number of well known scientists have lectured before the Institute and some of these papers we hope to have the pleasure of publishing in the PROCEEDINGS.

ERRATUM:

Page 96, sixth line from top—For "extremes" read "extreme."

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Vol. IV, No. 4 July, 1909

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OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. IV, No. 4 JULY, 1909

THE SLUGGISH DIATOM.

BY T. CHALKLEY PALMER.

Various considerations have been advanced in these pages for the purpose of showing how far theories of osmosis and the like are from being in accord with the particulars of the phenomena of diatom locomotion. The moment such theories become precise enough for examination, that moment they reveal themselves as untenable. As for osmosis, one is inclined to dismiss it, once for all, with the vivacious dictum of Pelletan: —"This explanation has one great fault: it explains nothing. 'Osmotic currents' is merely an expression wherewith to content oneself without being obliged to seek for anything further. Many authors, feeling how incomplete this pretended explanation is, have sought to study more thoroughly the movements of the diatoms * * * * in order to arrive at an explanation that explains."

Now as this study has progressed, it has been increasingly evident that there is nothing special in these movements, except the actual physical mechanism. Protoplasmic effort, here as elsewhere, results in motion, and is accompanied by the phenomena that usually go with expenditure of energy. The diatom is not passive, but energetic. It is energetic in the same sense that a spermatozoid is energetic, and it is not passive as a green leaf is passive while storing up starch in the sunlight and swaying idly in the breeze.

But how energetic is the diatom? Writers are not wanting who will have us believe that the crawling diatom gives only a feeble exhibition of power. They will remark that "the mass of the diatom is small, and the rate of progress slow." By implication, the force expended is almost negligible. But is it? The conclusion does not lie in the premises as stated. Let us, as heretofore in this discussion, try to consider the facts with some approach toward precision.

True it is that the diatom is small as compared with an elephant or a man. True it is, also, that the diatom's rate of progress is less, in miles per hour, than the normal rate of progress in elephant or man. All this is obvious enough. But since we are asked to appreciate these facts, let us do so. Only let us really consider them, and follow them to their logical consequences.

First of all, let us try to picture to ourselves how very small the diatom is as compared, for instance, with the human body. For the length of the diatom we may well enough take the microscopical measurement of 70 microns (μ). The micron is 1/25,000 of an inch. For the man, let us select an individual six feet high. This height is equivalent to

$$72 \text{ inches} \times 25{,}000\,\mu = 1{,}800{,}000\,\mu.$$

The ratio for length then becomes

$$70 : 1{,}800{,}000 :: 1 : 25{,}714.$$

The man is, in fact, 25,714 times longer than the diatom.

We have seen* that a lively diatom traveled at the rate of nearly two inches per hour. This is a certain number of times its own length. But suppose this diatom to be increased to the length of the man, and still to retain its ability to travel as many of its own lengths as ever in an hour. Evidently this monstrous diatom, increased 25,714 times the original length, will travel, not two inches, but

$$2 \times 25{,}714 = 51{,}428 \text{ inches per hour.}$$

---

* "Some Observations on Diatom Motion," Vol. II, No. 4, July, 1907.

Now there are 63,360 inches in a mile. The magnified diatom would then travel 0.81 mile per-hour.

This is not very rapid progress for a man. But let us remember that the diatom has been allotted an intolerable deal of heavy silica to a very small pennyworth of protoplasm. To make the comparison just, the man should be reduced to a layer of living slime, about three inches thick, lining the walls of a burial casket of rock crystal. Is it probable that the layer of slime, if so be it had power of thought, would deem itself passive during that hour spent in going nearly a mile?

It is to be considered, however, that neither man nor diatom is a line without breadth or thickness. The mere comparison for length does not give any adequate notion of relative sizes. Both man and diatom occupy space in three dimensions. If, in our endeavor to appraise the energy exhibited by the diatom, it were legitimate to postulate that the man progress as many times faster as he is larger in cubic content, we should proceed as follows: —

The man may be assumed to weigh 170 pounds. The specific gravity of the human body may be taken as that of water, which will be nearly enough for our purpose. Now 170 pounds of water would occupy 4620 cubic inches at standard temperature. A cubic inch is equivalent to

$$15{,}625{,}000{,}000{,}000\ \mu_3.$$

The volume of the man would then be 4620 times this number, or

$$72{,}187{,}500{,}000{,}000{,}000\ \mu_3.$$

The diatom, which was 70 μ long, may be taken as 14 μ wide and 10 μ deep. We have then for the volume of the diatom

$$70 \times 14 \times 10 = 9800\ \mu_3.$$

The ratio of volume, as between man and diatom, would be

$$\frac{72{,}187{,}500{,}000{,}000{,}000}{9800} = 7{,}366{,}071{,}428{,}571,$$

and this is the number of times we shall have to enlarge our diatom in order that it shall occupy the same volume as the man. We have now, indeed, such notion as enormous figures may give us, of the exceeding smallness of the diatom. We may further, as a mere matter of curiosity, calculate from this what the rate of progress would be in the man, if he were to go as fast in proportion to his bulk as does the diatom. The latter was found to crawl two inches in an hour. But this is 1/31,680 of a mile. The man should, on the hypothesis, go

$$\frac{1}{31,680} \times 7,366,071,428,571 = 232,514,881 \text{ miles per hour.}$$

This is at the rate of more than a round trip between earth and sun per hour.

This calculation, like the famous one as to what a man-sized flea should be able to do in the matter of jumping, fails to take into account any resistance of the medium traversed, and this is not so fatal to its value. But it also leaves out of the account — and this is of import so far as concerns our object of arriving at the output of energy exhibited by the diatom — all reference to the additional weight to be transported. Here we see at once why it is that energy in proportion to bulk is not evidenced in the form of locomotion in the organic world. Yet we are not warranted in saying that the man-sized diatom, because it is just as much heavier than normal as it is larger, would go no more than the original two inches per hour if it remained of the same vigor per cubic inch. This conclusion would be quite absurd. Indeed, we may demonstrate its incorrectness. *Bacillaria paradoxa* grows in colonies of ten to twenty or more individuals, like so many books in a symmetrical pile. Each diatom of the group is freely movable endwise on every other with which it comes in contact. The whole colony will contract until it forms a square block, or it will suddenly lengthen out until the individuals only adhere by their ends. During this manœuvre, the lowermost diatom, if in contact with the substratum, will scarcely move at all. The second will move nearly its own length, as do the third, fourth, etc., up to the twentieth. All these motions occur simultaneously. The topmost diatom has then passed through a distance of twenty times its own length, the next only nineteen times, and so on, the middle diatom having gone the average distance of the whole group, or ten times its length. The twenty diatoms, weighing just twenty times as much as one, have moved ten times the distance traversed by each separate diatom in the same interval. If one frustrule has gone at the rate of two inches per hour, the group has averaged twenty inches. So that there is, after all, if one could find the key to it, something in this fancy of energy in proportion to volume.

Let us return, however, to the difference in structure between man and diatom. The man may be considered roughly (no data being at hand) as three parts organic substance and one part bone by weight. The diatom, on the other hand, consists by weight of possibly one part protoplasm to nine of silica. Let the man, as before, weigh 170 pounds, of which 128 pounds will be flesh and 40 pounds bone. But a diatom of such weight would be only 17 pounds protoplasm capable of propelling, and 153 pounds silica to be propelled. We have calculated that a diatom of such length, if as vigorous in all its microns as its little brother of 70 μ, should go 0.81 mile per hour. But the 17 pounds of protoplasm does all this. At the same rate the 128 pounds of human flesh, if as powerful for locomotion as the diatom's protoplasm pound for pound, should not only propel itself and its 40 pounds of bone, at this same speed, but carry along at the same time 1112 pounds more of inert weight. We shall permit the man to dispose of this weight to the best advantage and so that it shall be the least possible drag upon him, only demanding that he depend alone upon his own vitality for its transportation. He may justly crawl along a shallow waterway and have the benefit of the buoyancy and lubrication of the water; only, in that case, he shall have this burden upon his shoulders in the form of a substance twice the specific gravity of water. Or, if it be suggested that the burden be too heavy for the human frame, and if we may be permitted to consider weight and distance as convertible terms, he may drop all this weight and transport himself and his bones 23.3 miles per hour in any way that seems good to him — so always he does it with his own native strength.

We might rest here with the notion that we had arrived at some adequate appreciation of the energy exhibited by the protoplasm of the crawling diatom. But we should deceive ourselves in this. For one of these diatoms will, without any trouble to itself, carry along with it, or push out of its way, weights of other filamentous diatoms not in motion, that may equal twenty times its own weight. These are frequent occurrences. We may safely say, therefore, that we have here the equivalent of the man progressing at 23.3 miles per hour, and dragging along with him a weight of 2520 pounds beside his bones; or else he may go unhampered 466 miles per hour.

We may now begin to see the little worth of the saying: "The mass of the diatom is small, its progress slow." If the whole mass is small, the mass of the animating protoplasm is yet smaller, and the work done by this minute portion of living matter is not small relatively, but very large. Proportionately to its volume, this protoplasm gives an enormous output of energy, and applies it for the purpose of locomotion in a way which, on the face of it, and so far as the arrangement is understood, would seem poorly adapted for the highest efficiency.

It is going to be said that this argument proves too much. It is going to be pointed out, with a certain show of glee, that the miserable jelly lining the walls of the diatom frustrule can by no possibility exhibit such capacity for work. I shall be told that if these estimates be correct we must call upon environmental forces to explain diatom motile activity. So shall osmosis lift again its diminished head, and Jackson and

Kozlowski smile again. But I am quite undisturbed. The conclusive answer is ready. Protoplasm can do greater things than this in the way of locomotion.

Among microscopic organisms endowed with the power of motion there are many of the same order of size with the diatom. Some of them progress through the water fifty or a hundred times faster than the diatom. Such is the gloriously beautiful, naked zoospore of *Œdogonium*, travelling buoyantly, flashing along like a green streak, with its buzzing ring of cilia. Such is *Trachelomonas*, in its heavy, flask-shaped shell, going its dizzy spiral with lashings of its long flagellum. Compared with these, the diatom is indeed sluggish, and would seem to stand still in a way to bring delight to Jackson and Kozlowski. But the mechanism of propulsion in *Trachelomonas* and the like is obvious, and all the world recognizes the motion as a result of protoplasmic energy. Had we started our calculation with *Trachelomonas*, instead of with the diatom, the outcome would no longer have been merely amazing; it would have become stupefying.

Yes; protoplasm is capable of these wonders.

A BACTERIOLOGICAL EXAMINATION OF THE DELAWARE RIVER WATER.

BY HOWARD WALKER FIELDS AND PERCY ELWOOD MEBUS.*

In interpreting the results of bacteriological examinations as regards the purity of the Delaware River at Easton considerable difficulty is experienced.

In a case of gross pollution, such as is seen by examining the results of the Martin's Creek samples at Bangor and at Martin's Creek, there is no difficulty. We know that the creek is highly polluted at both places, and hence the water can safely be condemned. The same can be said of the Pequest Creek at Belvidere. But with the water of the Delaware River at Easton, Pa., it is a different and more difficult problem. The water is not highly polluted, neither is it in good sanitary condition.

In judging whether the water of the Delaware River is safe or not several factors are involved : —

(1) Self purification of the stream.
(2) Longevity of pathogenic bacteria.
(3) Number of bacteria in the water.

(1) Under self purification there are five heads to be considered. They are, dilution, sedimentation, sunlight, aeration and oxidation and antagonism to the bacteria.

First, we note the effect of dilution. The two creeks mentioned above are considerably smaller than the Delaware River, and hence all the highly polluted water from these creeks is diluted. This is not a purification, but a sort of means of minimizing the danger, without removing it.

Next may be mentioned sedimentation. In the river there are several eddies between Easton and the Delaware Water Gap. In these eddies the current is slack enough to allow the bacteria to settle, and hence the water becomes partially purified. This is one of the good features of the river.

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* Abstract from thesis, Lafayette College, Easton, Pa., 1909. Through the kindness of one of the authors, Mr. Fields, a resident of Media, the Institute is enabled to publish this abstract. It is of especial interest as showing the factors to be considered in the examination of public water supplies.

The effect of sunlight, one of the best germicides known, on water, is also slight. Experiments have shown that bacteria of typhoid and other diseases are killed in a few minutes if exposed to direct sunlight. The energy of the sun's rays in penetrating the water is, however, so quickly absorbed that at a few feet below the surface it loses its power as a germicide and hence its effect in deep water is almost *nil*.

As regards aëration and oxidation, these are very valuable methods, but the effect on the bacterial content is slight. Oxygen is added to the water and it is improved in taste, but the bacteria are not destroyed to any appreciable extent.

It has been proved that algæ are antagonistic to bacteria. Because of their gelatinous character, they sweep through the water and entangle many bacteria and destroy them. We know there are algæ in the river during the summer months, and they undoubtedly rid the stream of many bacteria.

(2) The second of the factors to be considered is the longevity of pathogenic bacteria. This plays a very important part in judging of water supplies. From the observations of the current in the Delaware it was found that an average approximate velocity of the river was 3.7 miles per hour. The distance from Belvidere by scaling from the map along the river is found to be nearly fourteen miles. This would give the time of flow from Belvidere to be nearly four hours, and from the Delaware Water Gap to be about eight and a half hours. It is probably less than this, due to rapids in the upper regions of the river. Now typhoid bacilli have been known to live in water for several months, at the maximum, and several days at the minimum. Thus we see that if typhoid bacteria were deposited into the Delaware River at either Delaware Water Gap or at Belvidere, N. J., they would still be very much alive by the time they would reach

Easton, Pa. This was clearly shown several years ago (1900) when there was a typhoid epidemic in Belvidere, N. J. It was only a few days later that cases appeared in Phillipsburg, just opposite Easton, Pa., and the origin of the cases was traced to the Delaware River. This proves conclusively that the bacteria can travel this distance and thus be able to produce an epidemic.

(3) The next and last consideration is that of the number of bacteria in the water. There have been many attempts made to set standards by which the sanitary quality of the water would be fixed by the number of bacteria present. Many of these have been unsatisfactory, but of late many conservative sanitarians have agreed that a water having "less than 100 bacteria per c. c. is unpolluted, one with 500 bacteria per c. c. or over as being open to suspicion, and one over 1000 bacteria per c. c. as being contaminated by sewage."

Another authority gives us the following: "If the water contains over 500 bacteria per c. c. at 20° C., and over 50 bacteria per c. c. at 37° C., and shows *B. coli* in 1 c. c. samples, it shall be condemned."

As a result of careful consideration of all the factors concerned, the authors come to the conclusion that the water of the Delaware River at Easton, taken as a whole, without filtration, is unfit for potable purposes.

RABIES.

BY DR. JOHN REICHEL.[*]

Rabies is the name applied to an acute and highly fatal disease of animals and man. In man the disease is called hydrophobia (*hydro*, water; *phobia*, dread of), the name applying to a striking but not a constant symptom of the disease in man, not at all observed in the lower animals. Aside from rabies, the name of canine madness is frequently used, and by the phrase "the dog is mad" is meant or should be applied only to a dog with rabies.

As seen under natural conditions, rabies is always an inoculation disease; that is, it is communicated direct from animal to animal, or from animals to man, by the bite of an animal which already has the disease — in other words, communicated direct through a wound, usually inflicted by the teeth, introducing the infective material or virus of rabies.

The history of rabies can be traced back to time before the Christian Era, and it is generally accepted that Aristotle, who lived in the year 320 B. C., gave a distinct description of rabies when he said: "Dogs suffer from madness which puts them into a state of fury and all the animals that they bite when in this condition become attacked."

As early as the year 1591 we find recorded the transmission of rabies of wolves to man, which is most frequently the manner in which the disease is transmitted to man in parts of Russia, where a high mortality has been observed, explained to some extent by the fierceness with which this animal attacks man, the bite being generally accompanied by a great deal of tissue destruction.

In 1803, and for a number of years following, it was epizootic among foxes in southern Germany and Switzerland.

During the last years of the eighteenth and the beginning of the nineteenth century the disease spread over the whole of Europe, and at about this time made its appearance in America, the first outbreak being reported near Boston in 1768. In 1779 rabies was seen in Philadelphia and the State of Maryland, and in the year 1785 it was prevalent in many of the Northeastern States. At the present time, only a few of our extreme Western States along the Pacific coast can boast of the freedom of rabies, but from the rate of the present spread of the disease, it will be but a short time before rabies will have made its appearance in all the States. The disease is most prevalent in France, Belgium and Russia. Australia alone, of the recognized large countries, is free from rabies, due to the rigid quarantine regulations enforced upon all dogs imported. England, in the early eighties, practically succeeded in wiping out the disease by the enforcement of a law requiring the muzzling of all dogs and with strict quarantine regulations on imported dogs. At the present time, rabies is becoming more prevalent in that country, since the quarantine regulations are not enforced as they were.

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[*] Bacteriologist, State Live Stock Sanitary Board, Philadelphia, Pa. Paper read before the Institute, January 14th, 1909.

Animals Susceptible. — All the warm blooded animals are susceptible to rabies. Birds may contract the disease, and it has been observed in some experimentally inoculated and infected, that recovery may occur after showing symptoms of the disease. It is, however, generally accepted, that all other animals, when once they show symptoms of rabies, will die within a short period. The contrary has never been proven. In the dog, after the first distinct symptom is observed, death may follow shortly afterward, or it may require as long as ten days to take place.

Of the carnivora and omnivora, the dog stands out far from the rest as the most frequent host or propagator of the disease from animal to animal, or from animal to man. The wolf should come next in this classification, but of the domestic carnivora and omnivora the cat must here be mentioned, with the pig and the horse, in the order named. Of the wild carnivora and omnivora, the wolf ranks first, followed by the fox, hyena, jackal, badger, skunk and lion. Rabies is seen more frequently in carnivora and omnivora than in herbivora, and it may be said that infection from herbivora to herbivora, or from herbivora to carnivora and omnivora, is rare. Of the herbivora, the disease is most frequently seen in cattle, not so frequently in sheep and goats.

The fatal character of rabies in animals, including man, has attracted the most able men who have ever adorned the ranks of the medical and veterinary profession to the study of the disease. Of the famous men who gave great attention to it may be mentioned the well known surgeon, John Hunter, in England, Viborg in Copenhagen, Waldinger in Vienna, Hertwitz in Germany, and Pasteur in France. To Pasteur and his co-laborers, Nocard and Roux, we owe most of the knowledge we have of the disease, along with Babe, Van Gehucten, Nelis and Negri.

Cause of Rabies.—As to the cause of rabies, we have every reason to believe that it is due to a specific germ, but all attempts to isolate it have so far failed, but much of the nature of the virus is understood.

In an animal with rabies, the virus or causative agent has been demonstrated to exist in the saliva, salivary glands and in some parts of the central nervous system; namely, the brain and spinal cord and nerve ganglion. It is not generally accepted that flesh and blood contain the virus, although animals that have consumed the body of an animal dead of rabies are known to have developed the disease. The milk has been shown to contain the virus, both in animal and in man. Other glands, as the lachrymal and pancreas, may contain the virus. The contents of the stomach may also contain the virus, which may be taken as highly probable, in that saliva containing it is swallowed. The action of the gastric juice, however, soon destroys it.

The manner in which the presence of the virus can be demonstrated positively is as follows: Some of the saliva, or any of the body fluids that may contain the virus, or a small piece of the brain tissue, spinal cord, nerve ganglion or salivary gland may be taken and ground in a sterile mortar and an emulsion made and thinned out so that it can be drawn up through a hyperdermic needle into a syringe. The emulsion may or may not contain the virus. To demonstrate it positively, experimental animals are inoculated, generally the rabbit, but the guinea pig, cat or dog, or any of the warm blooded animals may be used. An injection of a small portion of the emulsion may be made directly into the muscle tissue or beneath the skin, but preferably beneath the *meninges*, or membranes covering the brain, which is very easily done following the operation of removing a small piece of bone of the cranium. The membranes covering the brain are then pierced with the hyperdermic needle and a few drops of the emulsion are forced beneath or between them. The skin at the seat of the operation is sutured and then sealed with cellodin. When the operation is carefully performed there is no pain, and in many instances the animal will frolic and eat immediately after the operation.

Like in all infectious diseases, a certain period elapses between the time of the infection or the inoculation and the appearance of the first symptoms of the disease, and this is what is known as the period of incubation, and in rabies this period varies with the different species of animals, to some extent with animals of the same species, and varies also with the location of the point of infection, as for example: A rabbit inoculated by placing the virus directly beneath the coverings of the brain will show symptoms of rabies in a much shorter time than a rabbit inoculated beneath the skin over the abdomen. For the same reason, a bite on the face is considered more dangerous than one on the hand, and one on the hand more dangerous than one on the foot.

The period of incubation in dogs varies from 15 to 60 days.

Longer periods have been observed. Dr. George H. Hart, of the United States Department of Agriculture, reports an instance in a dog in which the period was fully one year. Shorter periods of incubation than fifteen days have been reported, but they are very unusual. In cows the period of incubation varies from 14 to 70 days, in horses from 20 to 45 days, in cats from 15 to 60`days, in goats, sheep and swine from 14 to 60 days, in rabbits from 9 to 78 days, in guinea pigs from 12 to 50 days.

In man the period of incubation is alleged to vary more. Fourteen to sixty-four days are usually given, but it is reported to be shorter, and also much longer, in some instances.

In an act approved March 27th, 1903, the State Live Stock Sanitary Board was empowered to control rabies in Pennsylvania, and dogs known to have come in contact with dogs with rabies in the locality where rabies exists are placed under restraint for 100 days, which means that the dog is either confined or muzzled.

The virus contained in saliva from a dog with rabies has been successfully removed by filtration through a fine porcelain filter, proving that the causative agent is a solid body. Its activity is readily destroyed by heat, light and by drying. A five per cent. solution of carbolic acid, or a 1 : 1000 solution of corrosive sublimate destroys it in five minutes. Nitric acid and citric acid or lemon juice is said to kill it very quickly. The virus may be preserved in neutral glycerine unchanged for some time. It is quite resistant to putrefaction.

Galtiers found that the brain of rabbits dead of rabies buried twenty-three days still contained the virus.

The danger of man actually developing rabies when bitten by an animal depends upon the following: —

First — The animal inflicting the bite must have rabies. This has given rise to the opinion that the disease may appear spontaneously and that it is an intrinsic part of the dog's being which may creep out at any time under various extraneous conditions. This is as impossible as it would be for typhoid fever, tuberculosis, or any other infectious disease, to develop spontaneously.

Second — The bite must be one in which some tissue destruction has occurred, there should be a lessened continuity of the part, which gives a ready access to the virus. Experimentally it has been shown that rabbits which are shaven and exposed to the bite of a mad dog are more often infected than those bitten through the fur, even when the teeth penetrate deeply beneath the skin. The teeth are wiped dry of the saliva; therefore, a bite through clothing is not so dangerous as one directly on the skin.

Third — Danger is lessened if any one of the following or similar precautions be taken immediately after the bite is inflicted: A tourniquet may be applied around the limb to prevent absorption. The wound may be wrung to increase the flow of blood, cauterized with silver nitrate or any of the mineral acids.

It has been conservatively estimated that in man, where none of the above precautions had been taken, 16 per cent. develop rabies. Some series of cases show a much higher mortality. The mortality from bites of wolves with rabies is given from 60 to 80 per cent., as already stated, probably due to the severe bites this animal usually inflicts. Of dogs bitten by rabid dogs only 20 to 30 per cent. develop the disease. In cows bitten by rabid dogs the mortality is very much higher, 60 to 80 per cent. The time of the year or climate have no influence on the prevalence of the disease. The opinion is firm with many people that dogs are more liable to go mad during the so called dog days, which extend from the first of July to the middle of August.

Statistics show that the disease is prevalent throughout the year and seasons have very little influence.

Symptoms in Dogs. — In dogs, as in other animals, rabies is manifested in the furious, and the dumb or paralytic form, which, however, usually succeed each other in fully developed cases. Yet the furious phenomena may be entirely omitted, and again the victim may die in the early furious stage and the paralytic form not appear. The first symptoms of the furious form are a change in the disposition of the animal, which is manifested by distress and uneasiness and restlessness. Easily excited. At this stage the dog does not usually show a disposition to bite; he is still docile and obeys orders, though not so quickly as in health; he soon seeks solitude in the straw of his kennel; periods of restfulness befall him, alternating with marked excitement; he still shows affection for his master, and may even be more affectionate than is his habit. He may, however, be irritated by strangers or be much surprised by a touch or gentle blow, and here may inflict a bite.

The appetite is still good, and may even be excessive. Soon the restlessness becomes marked, constantly in motion, apt to tear carpet, rugs, or any obstacle.

He shows sign of delirium, looking off into space, apparently seeing some imaginary object; at times he will attack an imaginary enemy. He will still respond to his master's voice, but his attention cannot be held for any length of time. At this early stage the voice becomes modified, and this may be regarded as one of the most typical symptoms. Instead of the clear and sharp bark, which is natural, the latter part of the note becomes prolonged and of a higher pitch, going off into a plaintive cry, which has been likened to a dog fatigued in a chase. Although this symptom is a striking one, and quite constant, it may be lacking at times, and certain dogs remain quiet in spite of all attempts to excite barking. The appetite diminishes, and at about this time food is taken with more or less difficulty, and soon it is refused, swallowing being painful and difficult. The animal may appear to have a bone in his throat, a symptom which often tempts the owner to make a dangerous examination for the obstruction. The excitement is marked and the animal is now furious. If a stick or other article is presented to him, he seizes it with power; he attacks the bars of his cage. If at liberty, he attacks any object in his way, swallowing all sorts of foreign material, wood, stone, etc. At this time he begins to wander, running with his tail hung, mouth open, and eyes with a wild look. As a rule, he runs straight ahead, and does not turn out of his way to attack animals. The dog may travel tremendous distances, but is apt to return home, exhausted and covered with dust and blood. Very soon paralysis sets in, commencing in the hind legs, which extends, finally becoming generalized.

The course of the disease is rapid, lasting from six to ten days after the first symptoms. The furious form of rabies is most common; the dumb form is seen in 15 to 20 per cent. of all cases. The commencement of the dumb or paralytic form is the same as in the furious form, but the accesses of fury are lacking. The dog seeks secluded and dark places. The paralysis may commence in the various parts of the body, but as a rule affects just the muscles of the jaw, which soon drops; the dog being unable to close the mouth, the tongue protrudes. The animal is quiet and gradually fails to respond to a call. The progress of the disease is more rapid than in the furious form, death following in from four to five days after the first symptoms.

It is remarkable the great distance dogs will travel with furious rabies, and the mischief they can start up. Dr. E. C. Schroeder, Superintendent of Experiment Station, United States Department of Agriculture, in an article published last January, relates an instance of a rabid dog that started out of Washington, D. C., early in the forenoon, and was killed by a blacksmith, whose dog he viciously attacked, about seven miles from the city, early in the afternoon of the same day. During the few hours he was at large, after his escape from the yard of his owner, he passed along a mile of the city streets, through three suburban settlements, one of which is located fully a mile from the direct road between his point of escape and the place he was killed. He is known to have attacked four people, two horses, several cattle, and seven or eight dogs. The people and cattle bitten fortunately escaped injury; the one horse contracted rabies. This horse was brought to the experimental station and kept under observation until it died. Then rabies was reproduced in rabbits by the injection of a small piece of brain from the horse. The other horse was accidentally killed by an electric car shortly after it was bitten, and the dogs were killed as a precautionary measure.

In the summer of 1907 an outbreak of rabies was investigated with Dr. Peter J. Mertz, of New Holland, Lancaster County, Pa., on a farm upon which one cow died the day before and two died that morning. The brains of both were removed and brought to the laboratory of the Pennsylvania State Live Stock Sanitary Board and examined, and a diagnosis of rabies was made. On an adjoining farm another cow showed all the symptoms of rabies, and it was learned that a little more than a month before a dog roamed over the surrounding country and was killed near by, and that an examination of the brain of this dog at the laboratory resulted in a diagnosis of rabies. Before that outbreak was wiped out it necessitated the destruction of 154 dogs, 25 cows and 10 horses.

In the horse the symptoms are by no means characteristic. The history that the horse was bitten by a rabid dog may naturally aid the diagnosis, but to be absolutely certain experimental examination must be made on the death of the horse. Cattle drool and bellow a great deal, which are the two most striking symptoms. Both cattle and horses may develop the furious form, in which the horse may do himself a great deal of bodily harm, and cattle as well as horses are known to attack man as well as other animals. Both have been known to bite, which is unusual for a cow.

In man the symptoms are best made known in referring to one of the two cases reported by McCarthy and Ravenel in 1901: Case No. 1. Male, aged five, had been perfectly well up to May 13th, 1901. At that time he was bitten on the cheek by a stray dog. The wound healed and he appeared to be in good health until June 15th (42 days after the bite.) During the night he cried during his sleep. The following day he was up and about, but did not appear to be well. He ate very little during the day. Citrate of potassium was administered by the mother; free purgation resulted. June 16th, in the evening, he did not appear able to drink, as he asked for water, and then asked to have it taken away after attempting to drink it. June 17th he was admitted to the St. Joseph's Hospital, with temperature 101. He was very much frightened, evidently the initiative stage of the disease. He was tested as to his ability to drink, and every time he attempted to swallow there resulted a spasm of the glottis and the muscles of the neck and face. He refused to repeat the first attempt. In attempting to wash him, he became nervous, but was still very nervous from the tests at swallowing. At 7.30 P. M. he succeeded with much difficulty and after persuading, in drinking six ounces of coffee. Marked spasms occurred with each mouthful of the fluid swallowed. Shortly after this general convulsions ensued, the contraction of the legs being most marked. At 11 P. M. the pulse became very rapid, the patient very restless, and in a short time delirium set in. He imagined he saw his father under a sheet, with holes in his eyes. The expression, which from the beginning was very anxious, now assumed a terrified aspect. At 11.45 he was pulseless, did not react to stimuli, and died at 12 A. M. Autopsy showed nothing abnormal. Nervous system examined; showed changes as seen in rabies.

As there is no danger from a dog bite if the animal has not rabies, one recognizes the importance of an accurate diagnosis in each instance. The clinical symptoms are well enough pronounced to make the diagnosis a certainty in many instances, but in the majority of cases this is not so. The dog is usually killed as soon as he bites any one, or shows a tendency to become vicious. An autopsy will reveal no specific gross changes in any of the body tissues. Frequently foreign bodies are found in the stomach, swallowed during the furious stage of the disease. It frequently occurs, after a person is bitten by a dog, that some one will immediately look into the mouth of the animal. In case the mucous membrane or lining is black, it will be at once concluded that the bite is dangerous, even though the dog appears perfectly normal, but if the mouth happens to be red, it will be taken that there is no danger from the bite. This is entirely erroneous. The black color is due to a normal deposit of pigment in the mucous membrane of the mouth. It is present in a certain per centage of all dogs, and has no connection with rabies. The absence of any gross lesions may be taken as significant that rabies may be present.

The veterinarians of the State of Pennsylvania have been instructed that where rabies is suspected the animal shall be kept under observation for several days. A dog with rabies will not live more than ten days after showing the first symptoms; therefore, a dog that inflicts a bite and shows no symptoms, kept confined for more than ten days and at the end of that time shows no symptoms, can safely be considered free from rabies. Should he show symptoms at the time he inflicts the bite, he should be kept under observation for several days, and then he can be destroyed and the head, with a portion of the neck, can be sent to the laboratory of the Pennsylvania State Live Stock Sanitary Board, in Philadelphia, where the diagnosis will be verified. In the majority of cases, however, the veterinarian does not see the dog before death, and in these cases a laboratory examination alone can be depended upon.

Before the year 1900, the only way in which it could be shown that rabies did exist in a dead animal was by experimental inoculation. Rabbits inoculated with material of an animal suspected of rabies were kept under observation. If rabies existed the rabbit would develop the disease on an average of 22.5 days — some as short as nine days; longest period observed, 78 days. A person bitten was obliged to wait from 9 to 78 days to learn whether or not he or she was exposed to the disease.

Babe, as early as 1892, reports observation made microscopically of sections of the spinal cord and *medulla oblongata* ot cases of rabies in man and dogs. From his investigations he insisted that an increase or proliferation of the endothelial cells, which form the lymph sacks surrounding the nerve cells, with degeneration and destruction of the nerve cells, are specific pathological changes of rabies.

Van Gehucten and Nelis, after careful examination of the various parts of the nervous system of a man dead of rabies, found that in the nerve ganglion, particularly in the intravertebral ganglion, a marked proliferation of the endothelial cells, with nerve degeneration and destruction.

The examination then of those tissues wherein those changes described by Babe and Van Gehucten and Nelis took place, made it possible to determine the absence or presence of these changes, upon which a diagnosis could be made. Where the changes are present, a positive diagnosis can be made in from 36 to 48 hours, but if the changes are absent no diagnosis is made. The animal inoculation test is then relied upon. The changes are found in 95 per cent. of the positive cases, but that they are only seen in the cases of rabies has been disproven.

Ravenel and McCarthy found that the identical changes occurred in cattle afflicted with forage poisoning. They are also said to occur in animals dead of tetanus. Other investigators have found that the changes are sometimes seen, although rabies was not present. At our own laboratory, during the year 1906, well marked proliferation changes were found in seven cases that were later proven not rabies by animal inoculation tests.

In 1903 Professor Negri, of Pavia, described small cell inclusions in the nerve cells of the nervous system of animals dead of rabies, known as Negri bodies, which he not only regards of the highest diagnostic value, but as protozoa and the cause of rabies. The bodies are easily demonstrated in sections of the nervous system in the nerve cells. The size varies, some being 20 microns in diameter. Larger forms are frequently seen. The shape is generally round, frequently oval, but other forms are occasionally seen. They possess a distinct structure, show dark staining granules in the centre of the round forms or ends of the oval or other forms, and are surrounded by a rosette like structure, which Negri describes as a membrane composed of two layers.

A total of 576 cases has been gathered, in which Negri bodies were found, and to this may be added 350 examined in the laboratory of the State Live Stock Sanitary Board, in which the bodies were also found. Negri bodies are not found, although rabies exists, in one to three per cent. of the brains examined. As yet the bodies have never been found in the saliva or other secretions of the body, nor have they been found in the peripheral nerves. It must be yet reported that the Negri bodies were found in any other disease. Much work is being done upon the relation these bodies have to the cause of rabies. Many views are held, but none have as yet been proven. Negri bodies cannot be regarded as the cause of rabies, but this by no means reduces their value in the diagnosis of the disease. More than nine years ago it required on an average 21 days to confirm a positive diagnosis by the use of the animal inoculation test. With the discovery of the proliferation changes described by Van Gehucten and Nelis, in 1900, it was possible to make a diagnosis in a few hours. Although this method had its weak points, it was used and relied upon until the discovery by Negri of the so called Negri bodies.

To Dr. Anna Williams and May Murray Lowden, of the New York Board of Health, *must be* given the credit for the shortest method in the demonstration of Negri bodies.

Small pieces of the brain tissue are taken, in which the bodies are most frequently found, usually the *hippocampus major* or the *cerebellum*, and placed upon the end of a glass slide and covered by another. The first slide is then drawn toward the end of the second slide, spreading the tissue over the slides in a thin layer, making two smear preparations. The smears are then fixed upon the slides by placing the slides in absolute alcohol for several minutes. For staining, Loeffler's alkalin methylene blue and basic fuchsin in the right proportions are used. The slide is washed in water and dried between filter paper, after staining, and examined microscopically.

The smear, properly spread and stained and examined, shows the structure of the larger nerve cells stained a light blue, the Negri bodies a pink or light red, with dark, granular bodies in the centre. In this way Negri bodies can be demonstrated in several minutes, and a diagnosis quickly established.

TREES AND SHRUBS OF THE COURT HOUSE LAWN, MEDIA.

Through the interest taken in the matter by Hon. William B. Broomall, one of the Common Pleas Judges of Delaware County, the County Commissioners have recently arranged with this Institute to have the trees and shrubs of the Court House lawn properly named and permanently labelled. While not an extensive collection, it is of considerable variety and interest. There are some horticultural varieties in the list, and for this and other reasons it was decided to have the naming done by an expert nurseryman. This has now been done, and appropriate labels are in preparation. These labels are to bear both the English and the technical names. It will be noted that the Latin names, as given in the subjoined list, are without cited authorities. This is possibly in accordance with horticultural usage, and for the purpose in view will scarcely lead to confusion, serving well enough in fact, how far soever it may fall short of the standard set for naming plants in formal scientific publications. Three trees and a few shrubs still await the flowering season for the determination of their specific names.

The present Court House dates from about the year 1850, at which time the County Seat was removed from Chester to Media. Many of the trees in the lawn were planted in the autumn of 1851 by Charles F. Hewes, still living at Fairview, Delaware County, at the age of eighty-two. He has recently given to Mr. C. Howard Lungren, of Swarthmore, Pa., a gentleman interested in the work of the Institute, the following particulars: —

Jacob Hewes, the father of the present Mr. Hewes, was a nurseryman, his place being on the west side of Chester Pike, between Crum Creek and Eddystone, on what is now the McIlvain tract. The trees were planted by Mr. Hewes, acting for his father, and under the direction of William Trainer, then a member of the Board of Commissioners. Mr. Trainer instructed Mr. Hewes to plant twenty to thirty feet apart, and not in rows, "in order that they might look as natural as possible." There were a few maples in the lawn already, but these must have been of very recent planting. Mr. Hewes thinks the trees were mostly elms, beeches and ash trees. He used a "ten foot pole" in measuring, and thinks none were planted less than ten feet apart.

Mr. Lungren also finds a most interesting statement concerning the matter of the Court House trees in a small pamphlet of sixty pages, under date of 1889, entitled "Media, Penna. Its History and General Advantages," etc., published by "A Committee of its Citizens," and printed by the press of the *Delaware County American*. An article on the history of Media is from the pen of Hon. John M. Broomall, a name of weight in this connection. We quote as follows from this pamphlet: —

> "In the Court House Square of Media are many trees, the selections and gifts of John Evans.
>
> "They are the Turkey and Bur Oak; *Paulownia imperialis*, *Koelreuteria paniculata*, Elms, Ashes, Lindens, Sweet Gum, Magnolias, Horse Chestnuts, Maples, Beeches and Birches in variety; with Larches, White Pine, Norway Spruce, Balsam, Fir and other Conifers; and shrubbery in choice varieties."

The John Evans here named is he who died in 1862 and left on Ithan Creek that botanical garden the contents of which still amaze the visitor with their extent and variety. He was of the breed of Bartram and Marshall, though of a later date, and his collections greatly surpassed those of his famous predecessors.

The reference to John Evans and his part in the planting of the Court House trees, in this pamphlet, was written at a time when an error on this subject would scarcely have passed a committee of citizens without challenge. It reads like a correct statement of fact by a contemporary. It does not interfere seriously with the recollections and verbal statements of Mr. Hewes, and it may with good reason find acceptance.

It would seem highly probable that many of the maples still on the lawn were of a later planting. The slow-growing Turkey Oak and Mossy-cup Oak, and the English Beech, etc., look all of their reputed years, and are, with their accompanying trees, appropriately scattered ; while the sugar maples and the like are more regularly arranged, and have, within the recollection of residents not yet old, overshadowed and been the ruination of specimens of an older growth. Not a few rare species have thus been supplanted, and all record of them is now lost. Official ignorance, also, has been responsible for some wanton destruction, for time was when the chief end of man was thought to be the wielding of an axe ; and at one period the custodians of this property took much pride in the thorough manner in which they had "trimmed up" the lawn and eliminated sundry slow-growing specimens, to the end that those maples "might have a show." Noonday destruction wasted after this manner until Dr. George Smith and Dr. Edwin Fussell, officers of this Institute, good old gentlemen botanists and tree lovers, friends of John Evans and defenders of his far-brought treasures, cried aloud in protest to the Board of Commissioners. Thereupon it was arranged that no more tree cutting should be done without the advice and consent of the Institute. This argeement, howsoever lacking in power to bind the action of subsequent boards, has served more or less as a precedent, and has had, decidedly, a beneficial effect. Choice and rare trees are no longer casually destroyed at the chance whim of a janitor who may perhaps be short of firewood. The very respectable survivors of the collection, duly labelled and under the powerful protection of high officials, may reasonably be expected to live out all their days. John Evans rests these forty years and more in his beloved Radnor garden. Charles F. Hewes is old and blind. But the trees go on blooming year after year; and we well may hope that they may continue to find defending friends when he who planted, and they who now protect, shall likewise have passed away.

The following is the complete list of trees and shrubs: —

Althea, or Rose of Sharon (Hibiscus syriacus, var. ardens)
Althea, or Rose of Sharon (Hibiscus syriacus, var. alba plena)
Althea, or Rose of Sharon (Hibiscus syriacus, var. alba simplex)
Arbor Vitæ, Chinese (Biota orientalis)
Ash, Black (Fraxinus nigra)
Ash, Flowering (Fraxinus ornus)
Ash, White (Fraxinus alba)
Austrian Pine (Pinus austriaca)
Barberry, Common (Berberis vulgaris)
Beech, European (Fagus sylvatica)
California Privet (Ligustrum ovalifolium)
Catalpa (Catalpa speciosa)
Cherry (Cerasus)
Deutzia (Deutzia crenata)
Dwarf Box (Buxus suffruticosa)
Elm, American (Ulmus americana)
Elm, Camperdown (Ulmus pendula)
Elm, English (Ulmus campestris)
Elm, Weeping (Ulmus rugosa pendula)
Empress Tree (Paulownia imperialis)
Golden Bell (Forsythia)
Hercules' Club (Aralia spinosa)
Honey Locust (Gleditsia triacanthos)
Horse Chestnut (Æsculus Hippocastanum)
Horse Chestnut (Æsculus rubicunda)
Hydrangea (Hydrangea paniculata grandiflora)
Japan Quince (Cydonia japonica, Pyrus japonica)
Japanese Varnish Tree (Koelreuteria paniculata)
Kentucky Coffee Tree (Gymnocladus canadensis)
Larch, European (Larix europaea)
Lilac (Syringa)
Linden, American (Tilia americana)
Linden, European (Tilia vulgaris, var. rubra)
Magnolia (Magnolia)
Maple, Norway (Acer platanoides)
Maple, Silver (Acer dasycarpum)

Maple, Sugar (Acer saccharinum)
Maple, Sycamore (Acer pseudo-platanus)
Meadow Sweet (Spiraea)
Meadow Sweet (Spiraea opulifolia)
Meadow Sweet (Spiraea Thunbergii)
Mock Orange (Philadelphus)
Mulberry (Morus)
Norway Spruce (Picea excelsa)
Oak, Mossy Cup (Quercus macrocarpa)
Oak, Turkey (Quercus cerris)
Oak, White (Quercus alba)
Smoke Tree (Rhus Cotinus)
Sweet Gum (Liquidambar Styraciflua)
Weigela (Diervilla)
Wisteria (Wisteria)

THE THERMODYNAMICS OF ELASTIC BODIES.

BY C. M. BROOMALL.[*]

The elasticity of a body may in a general way be defined as the ability it possesses of regaining its original shape or volume after a deformation or change of volume caused by an applied force. The measure of this elasticity, its coefficient of elasticity, is specifically defined as the ratio of the unit stress to the unit strain. That is, other things being equal, that body which requires the greater force to produce a given deformation or change of volume, has the greater coefficient of elasticity, or in general terms is spoken of as the more elastic. The elastic force of bodies depends upon various circumstances, as for instance, the material of the body, the manner of application of the force, etc. Thus there are the coefficient of bulk elasticity, the coefficient of rigidity and Young's modulus. The former two are the coefficients of pure strain, while Young's modulus is a quantity depending upon both bulk elasticity and rigidity. The latter is the coefficient most commonly met with, being applicable to the usual cases of bodies under compression and tension.

With ordinary solid bodies and under ordinary circumstances it is assumed that the coefficient of elasticity of a body is independent of temperature. This, however, is far from being true. It is found that the elastic force of a body is always some function of its temperature. In some cases the elastic force increases as the temperature rises, and in other cases the elastic force is lessened by an increase of temperature. In other words, we may class all bodies either as

(1) Those whose coefficient of elasticity is a direct function of the temperature, and

(2) Those whose coefficient of elasticity is an inverse function of the temperature.

The cause of this difference is not fully known. It depends upon both the intrinsic nature of the substance of the body itself as well as upon the manner of application of the force — and perhaps upon other causes. As examples there may be cited the following facts which have been both theoretically and experimentally established : —

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[*] Summary of talk before the Physical Section of the Institute.

The heating of a body under ordinary circumstances increases its elastic resistance as regards cubical compression :

The torsional rigidity of a wire is diminished by an increase of temperature, at least in the case of the commoner metals :

A spiral spring under tension has its elastic force diminished by an increase of temperature :

A bar subjected to end thrust acquires a higher coefficient of elasticity when its temperature is raised :

On the other hand, a bar or wire under tension loses some of its elastic force when heated :

A rubber band under tension acquires an increased elastic force upon heating.

In the foregoing examples it goes, of course, without saying, that the effect of cooling is to produce the corresponding inverse elastic effects.

As before stated, a satisfactory explanation of the cause of these effects is not yet forthcoming. For the present it is better to accept them as experimental facts. It is seen that two principal factors concerned in the varying actions are first, the intrinsic nature of the material, as evidenced by the steel wire and the rubber band under tension ; and second, the nature of the strain, as illustrated by the steel bar under compression and tension respectively.

Corresponding to these effects of heat upon elastic force are certain inverse heat effects resulting from mechanical strain produced in bodies by the application of force. The general thermodynamic principle underlying these is set forth in the Encyclopedia Brittanica in the article "Elasticity," Volume VII, as follows : —

"Heat is produced when a solid is strained against, and cold when it is strained by yielding to, any elastic force of its own, the strength of which would increase if the temperature were raised. And again, cold is produced whenever a solid is strained by opposing, and heat when it is strained by yielding to, any elastic force of its own, the strength of which would diminish if the temperature were raised.''

Two of the examples above cited, namely, the spiral spring and the rubber band under tension, furnish the means of preparing a simple apparatus which at first glance seems to act in a manner somewhat paradoxical.

Let there be hung from appropriate points of attachment a spiral spring and a rubber band, each supporting an equal weight at the same level. Assuming the two systems at the same temperature and the weights at the same elevation, comparisons between the two cases are easily made. Let a source of heat be now brought close to the bodies. The temperature of both spring and rubber will rise and after a certain time they will both be at the same increased temperature. But the spiral spring will have elongated and the rubber band shortened, and the weights will have been respectively lowered and raised. The system containing the spiral spring, which we will call S, will therefore have lost potential energy, and the rubber band system, R, will have gained potential energy, both effects, however, resulting from the same cause.

On the face of it this looks a little like a contradiction of the law of the conservation of energy. In other words, we are giving heat energy to system S, and yet after things have come to a state of temperature equilibrium we find the potential energy to be less.

Again, let the heated body be now removed and the systems cooled to the original temperature. The two weights will return to the original level, and system S will now have gained potential energy as a result of taking away heat. This again, at first glance, appears odd.

Of course any difficulty in understanding the above actions rests upon the fact that we are not distinguishing properly between the sensible temperature of a body and the actual heat transferred. If the heat energy is considered under two heads, namely, that required to change the sensible temperature of the systems, and secondly, that concerned in the changes of potential energy, it is easy to show that the actions are, as of course they must be, in accordance with the law of the conservation of energy.

In the first place it is to be noted that the amount of heat required to produce the sensible thermometric change (together with any heat absorbed or released in other molecular work) is greater than the heat equivalent due to raising or lowering the weights. When the systems are heated, less heat in comparison is absorbed by system S, the spiral spring, than by system R, the rubber, by an amount equivalent to the difference of level of the weights at the higher temperature. Upon cooling the two systems, the heat radiated by system S is less, comparatively, than that given off by system R, because in the first case energy is required to raise the weight to the original level, while in the second case heat has resulted from the falling of the weight. Thus each system in returning to the original position gives out just the amount of heat it absorbed in the first change. The difference between the two cases is that the actual transfer of heat energy, other things being equal, is greater in system R than in system S.

These considerations show that the actions are easily brought into consonance with thermodynamic theory.

If we limit our consideration to the second or cooling-off phase of the operation of system S, with the spiral spring, it is almost startling to see actual mechanical work done by taking away heat energy from the system. And, indeed, this is just what is taking place, although as a matter of fact we are only reaping the benefits of the previous heated condition of the body. That is, mechanical work is obtained from the heat energy of system S when by the proximity of a cold body a flow of heat is caused to take place from the warm system to the cold body. The direction of flow, whether into the system or out of it, is a matter of indifference, provided the heat engine is properly arranged to take advantage of the heat flow. If operations are started with systems S and R at the same temperature, and the initial step be that of cooling, there occurs in case S an actual increase of potential energy, despite the fact that heat has been abstracted from the system. The heat abstracted is that due to the fall of temperature, less that corresponding to raising the weight. As a matter of fact both systems S and R have less total energy at the end of the cooling process than before. When system S is again heated to the original temperature the weight falls, and the transfer of heat to the system is that necessary to raise the temperature, less the heat equivalent of the falling weight.

The action of system R with cooling as the first step, is evident without comment.

It is interesting to note that the action of the spiral spring with cooling as the first step, is somewhat on a par with the mechanical force which bursts a water pipe on freezing. In this case we have a flow of heat away from the water doing the work of breaking the pipe. Another somewhat similar example is the additional energy obtained in a steam engine by condensing the exhaust steam.

In all these actions it is not that the total energy of the system is increased by taking heat from it, but only that by cooling a flow of heat is caused to take place which does mechanical work in the heat engine, be it spiral spring, freezing water or steam engine.

MINUTES OF MEETINGS.

MAY 6, 1909.—Annual meeting of the Institute, President T. Chalkley Palmer presiding. The annual reports of the Board of Curators, Treasurer, etc., were received. The following officers were elected to serve during the coming year:

President—T. Chalkley Palmer
First Vice President—Henry L. Broomall
Second Vice President—Charles Potts
Secretary—B. M. Underhill
Treasurer—C. M. Broomall
Librarian—Henrietta K. Broomall
Curators—Edgar T. Miller and Homer E. Hoopes

On motion the Curators were authorized to paint the Institute building. Report was made that Section A, devoted to the consideration of all branches of science, had been organized with Albert S. Barker as Director and Sanford Omensetter as Recorder. It was stated that the intention was to hold meetings weekly throughout the summer months, and that the minutes of these meetings would be reported in the PROCEEDINGS. Under the head of scientific business, Henry L. Broomall made some remarks upon the history of the change of accent in such words as *deficit*, *inquiry*, *injury*, etc. He stated that usage had changed the accent in these words from the second to the first syllable, and that this was the tendency in modern English. He stated that scientific words little used retain the Latin pronunciation, but that when they get out among the people the tendency to throw the accent forward frequently overcomes all classic rules. Mr. Broomall called attention to the fact, in this connection, that there were over 800 words in the New Century Dictionary, down to the letter "L," which have more than one pronunciation given. On motion adjourned.

JUNE 3, 1909.—Regular monthly meeting, with President T. Chalkley Palmer in the chair. The usual reports of committees and officers were received and current business transacted. C. M. Broomall reported that he had secured a fossil tree stump which it was intended to have placed on the lawn of the Institute. Additions to the library and museum were announced. Following the business portion of the meeting there took place the usual discussion of current scientific matters. On motion meeting adjourned.

JULY 1, 1909.— Regular monthly meeting, with Vice President Henry L. Broomall in the chair. The usual reports of officers were received and current business transacted. The following additions to the library were announced : Reports of the Warren Academy of Science ; United States National Herbarium, Volume 12, Parts 8 and 9 ; "The Crinoids of Tennessee," Smithsonian National Museum ; "Insect Pests of Clover and Alfalfa," Bulletin University ot Illinois ; Proceedings Boston Society of Natural History, Volume 34, Number 7 ; "New Echinoids from Mississippi," Field Museum of Natural History ; Proceedings United States National Museum, Volume 35 ; "The Microscope," by Carpenter. On behalf of Section A it was announced that T. Chalkley Palmer had discovered a new species of diatom, for which he proposed the name *Navicula socialis*. Through the kindness of Dr. Anna E. Broomall a section of wooden water pipe, found while excavating for the cellar of the new Wanamaker building, Thirteenth and Market Streets, Philadelphia, was presented to the museum. This pipe was laid in 1800 and found in 1900. Considering its century underground, the state of preservation was remarkable. In answer to a question, C. M. Broomall explained the theory of single and double rainbows and the accompanying polarization of the light. He also exhibited a specimen of the ghost flower (*Monotropa uniflora*), which after being placed in alcohol had turned black. The coloring matter of the flower gave a strong purple solution in alcohol. Miss Amy Markley presented to the Institute an old copper plate, with a print made from it, both found in the Emlen house (built 1794, at Yearsley's Mill) when Samuel Markley bought and took possession of the place.

MINUTES OF SECTION A.

MAY 13, 1909.—Lewis Kirk, with blackboard illustration, explained the XLVII Proposition of Euclid: also interesting facts concerning hexagons. T. Chalkley Palmer exhibited some diatoms taken from a spring water trough on a road near Dismal Run. These diatoms were amongst the smallest of naviculoid forms, measuring not more than from 6μ to $7\frac{1}{2}\mu$ in length. Albert S. Barker exhibited *Batrachospermum moniliforme*, in fruit, also the antheridia of a moss, with the antherozoids fully developed and active. A letter from Dr. John Marshall to Dr. Reichel, on the reaction between potassium permanganate and formaldehyde, was read to the Section. This subject had been presented by C. M. Broomall. The effects of varied chemical treatment upon the colors of flowers was the subject of remarks by C. M. Broomall, who gave the results of numerous experiments.

MAY 20, 1909.—E. V. Streeper, Jr., submitted for determination a worm taken from Philadelphia tap water. Charles Potts spoke on the mode of locomotion of the grub worm. Dr. B. M. Underhill presented a specimen of *Hypoderma lineata*, commonly known as the ox warble, in the larval stage. Albert S. Barker exhibited, under the microscope, living specimens of *Hydra viridis*; also mounted slide of *Hydra vulgaris*, showing the thread cells. Miss Pennell exhibited snake skins and palmetto fibre from Florida. Charles Potts, speaking of eels, stated that when a boy he found, in an underground passage below Fairmount Dam, Philadelphia, a great number of eels about two inches in length, clinging to the walls. Sanford Omensetter presented two living specimens of the common garter snake.

MAY 27, 1909.—Dr. David Dalton, of Sharon Hill, exhibited slides of human blood under both normal and abnormal conditions; also slides of the bacilli of tuberculosis, typhoid fever, yellow fever, anthrax, and others; also, a cross section of a kitten's tongue. T. Chalkley Palmer exhibited a slide of *Pinnularia*; also a *Navicula*, stained to show the gelatinous sheath; also a *Closterium* burned on the cover glass to show that the cellulose walls contain sufficient oxide of iron to preserve the shape of the organism after the vegetable matter has been destroyed. Albert S. Barker exhibited a preparation of the stamen hairs of *Tradescantia Virginica*, showing the streaming of the protoplasm; also sections through the conceptacles of *Fucus*. Mrs. Henry L. Broomall presented specimens of the Mexican jumping bean. Dr. Starbuck spoke of an anærobic organism found in the disease known as Vincent's angina, and stated that there is also found in this disease a motile spirillum bacillus.

JUNE 10, 1909.—Carolus M. Broomall exhibited a section of the wooden water pipe laid in Philadelphia in 1800, and dug up during some recent construction work. He called attention to the remarkable preservation of the wood. Sanford Omensetter described the actions of a song sparrow in attendance upon a young cowbird. Albert S. Barker exhibited a living centipede, captured on South Orange Street, just outside of Media, which was added to the permanent collection of the Institute; also the sporangia of certain ferns, in which the process of scattering the spores was shown under the microscope; also a slide of blackberry rust; also *Utricularia* from the pond in the Botanic Garden, University of Pennsylvania. C. M. Broomall exhibited an Indian axe head having *two* grooves for the attachment of the handle.

JUNE 17, 1909.—Carolus M. Broomall exhibited a *Zygnema* which had developed in water drawn in the Institute building. Sanford Omensetter exhibited *Baptisia tinctoria* and described the characteristics of the species. Albert S. Barker exhibited living specimens of *Plumatella* and *Hydra vulgaris*; also pollen of the hollyhock.

JUNE 24, 1909.—C. Edgar Ogden exhibited maple leaves covered with honey dew. C. M. Broomall exhibited calcite showing interference colors. T. Chalkley Palmer exhibited diatoms from Swan Lake, Oregon, which he had received from William A. Terry, of Bristol, Connecticut. Carlota Broomall exhibited specimens of the "sea horse." T. Chalkley Palmer announced the discovery of a new species of diatom, for which the name *Navicula socialis* had been proposed. Specimens of this diatom were shown under the microscope. It resembles *Navicula viridis*, but differs from the latter in that it occurs in groups of four individuals. Dr. B. M. Underhill exhibited a biting fly, which is very troublesome to horses; also *Musca vomitoria*, and in connection with this exhibit he gave a talk, with charts, etc., on the life history of this insect; he also exhibited the larva of *Corydalis cornuta*. William B. Broomall, Jr., exhibited the larva of a "lady bug." Sanford Omensetter presented a collection of *Monotropa uniflora*. Albert S. Barker exhibited under the microscope living specimens of *Conchilos volvox*, *Cyclops*, *Cypris* and *Daphnia*.

JULY 8, 1909.—C. Edgar Ogden spoke on "honey dew." This was found usually on the Norway maple, but had been seen also on the white oak. Carlota Broomall exhibited a specimen of agate. Carolus M. Broomall presented a yellow billed cuckoo, found dead on the porch of his residence, but showing no evidence of injury; also a number of specimens collected by E. V. Streeper, Jr., at Atlantic City, including periwinkle eggs, a fiddler crab, a hermit crab, a medusa and the inside shell of a squid. Dr. B. M. Underhill exhibited a *Fucus* gathered at Longport; also a *Tabanus atratus*. Sanford Omensetter presented *Orthosoma brunnea*. Carolus M. Broomall described certain experiments with polarized beams from rainbows and moonlight.

JULY 15, 1909.—Albert S. Barker described the resolutions of vibrations in plane polarized light, and with a table polariscope exhibited the interference colors of mica and selenite films, and various crystallizations, including salicin and benzoic acid. The effects of circular polarization were shown by a quartz plate. Sanford Omensetter exhibited a living specimen of the "little brown bat." Carolus M. Broomall stated that he, with Dr. B. M. Underhill and Sanford Omensetter, had succeeded in taking the respiration and pulse of the bat above mentioned, the respiration being 160 and the pulse 448! Dr. B. M. Underhill presented a specimen of the brown longhorn. Albert S. Barker exhibited under the microscope the stellate hairs of the *Deutzia*.

JULY 22, 1909.—Carolus M. Broomall made some remarks concerning the proper curves for a private roadway forming the approach to a dwelling, providing for the approach of an automobile and its departure, passing around a grass plot or shrubbery. Sanford Omensetter exhibited a branch of a shrub or small tree which is growing on a lawn in Springfield Township. Charles Potts stated that it was known as a Japanese orange. Sanford Omensetter stated that he had seen schools of young catfish in a landlocked quarry hole on the premises late of Charles G. Ogden, in Springfield Township, and wondered how they got there. T. Chalkley Palmer quoted Izaak Walton, who said it was possible for them to be conveyed from pool to pool via the heronshaw. Carolus M. Broomall spoke of the fossil tree stump which he had caused to be brought from the grounds of the Shortlidge School and placed in the Institute yard. Charles Potts suggested that the fossil had been formed by the gradual substitution of slaty, siliceous matter in place of the decaying substance of the tree. The condition of the Media water supply was the subject of general discussion. T. Chalkley Palmer had been observing bees, and was amazed at their intelligence. In this connection he quoted Maeterlinck, who had made interesting experiments with these insects. James Vail spoke of ice crystallization observed by him in the Alps. These crystals were formed on the surfaces of ice sheets and could be swept off. T. Chalkley Palmer had noticed similar crystals in an old ice house, the temperature at that time being —25° or —30°. In the case observed in the Alps he supposed it was frozen dew. Dr. Starbuck described a battle between ants which he had observed in his yard, and which lasted several days. He separated one pair of combatants, and they remained clinched for five hours. Albert S. Barker exhibited snail eggs collected from a pool in the University of Pennsylvania Botanic Garden. Under the microscope snails in various stages of development were seen. Some, with their proper shells fully formed, were moving about almost as freely as if already hatched. Referring to *Hydra vulgaris*, exhibited June 17th, he stated that a bud which had appeared early that evening, matured and left the parent stem at the end of about fifty hours.

JULY 29, 1909.—Carolus M. Broomall submitted samples of water taken from Media reservoir, containing organisms which were identified by T. Chalkley Palmer and others, and included *Spirogyra* and *Peridinium*. Dr. B. M. Underhill exhibited fossil crinoids from Burlington, Iowa, and explained their relationship to existing forms, their place in zoological classification, etc. Carolus M. Broomall presented a fungus having a powerful and unpleasant odor. He had experimented on it with Millon's reagent, and it appears that the odorous portion takes on a more pronounced color than the other parts. William B. Broomall, Jr., exhibited a petrified mussel; also an Indian implement (?). Albert S. Barker exhibited hairs of the elk and the moose, the former being highly elastic. These had been obtained from Charles A. Voelker, of Aldan, who had called attention to their elasticity.

INSTITUTE NOTES.

Mr. Robinson Tyndale, Member, has presented to the museum of the Institute a bow and three arrows of the kind used during the late war between China and Japan. The Chinese troops which came to the front from the interior of China were in many cases only armed with bows and arrows. The specimens in the museum were brought from the interior of the country by one such company, and, through a correspondent in China, Mr. Tyndale was able to get possession of them. Mr. Tyndale has also presented a couple of sections of basaltic rock, brought from Haida, in Austria. Columns of this material, similar in shape to those of the Giants' Causeway, in Ireland, are found in great number in Haida, and are used for hitching posts, curb stones, steps, etc.

The trees in the Court House Square, Media, have had placed upon them proper labels with both common and botanical names. Elsewhere in this number will be found a list of the trees and what little is known of the history of their planting.

The present number of the PROCEEDINGS completes Volume IV. Elsewhere will be found title page and index for use in binding into book form.

Sanford Omensetter reports *Aster patens* in flower near Whiskey Run, Delaware County, on July 18th.

The Institute building has just been painted — something that has been needed for some time.

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PROCEEDINGS

OF THE

Delaware County Institute of Science

Carolus M. Broomall, Editor.

PUBLICATION COMMITTEE:
T. Chalkley Palmer, Chairman; Henry L. Broomall,
Trimble Pratt, M. D., Charles Potts,
B. M. Underhill, V. M. D.

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PROCEEDINGS

OF THE

Delaware County Institute of Science

LIBRARY
NEW YORK
BOTANICAL
GARDEN.

Vol. V, No. 1 October, 1909

THE INDIAN NO PROBLEM.*

BY GEN. R. H. PRATT, U. S. A., RETIRED.

From a magazine for October, telling about some Indians, I abbreviate as follows: —

EXTRACTS.

"Fred Big Horse, a Sioux Indian, is now an extensive ranch owner in South Dakota, having taken up this work after leaving the Government Service as additional farmer. In a letter recently received from him, he says: 'I am interested in Christian Society work; I am now President of the Brotherhood Christian Unity. This organization is the largest among the Dakotas, and has over $1000 invested in its work. The organization has become a recognized power for good.'"

"Mr. Reuben Quickbear is at present leading a delegation to Washington, D. C., to confer with the Secretary of the Interior on certain treaties. He has been a delegate to Washington several times before. Mr. Quickbear has been clerking for the Jordan Merchandise Company. He has a good home and excellent stock. He is secretary of the General Council of this reservation. It is through the influence of this Council that the old chief's influence is dying out and the influence of progression is taking its place."

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*Lecture delivered before the Institute.

"Mr. Stephen K. Murray learned the carpenter's trade and is now a good builder. Since returning to the reservation he has made himself useful in many ways, and at various times has helped to build churches in the Dakotas."

"Mr. Raymond B. Stewart is doing well. He has a good home and is a successful farmer. He is a painter by trade, and during the spring and summer months works at his trade."

"Mr. Morris Walker is a successful farmer, and has a good home."

"Mr. Ralph Eagle Feather learned the carpenter's trade, and has, until recently, been carpenter at the Agency. He left this position to work for himself."

"Chauncey Yellow Robe has been doing well, and is at present instructor in farming at the Rapid City school."

"Clarence W. Thunder is assistant district farmer here at the Agency."

"Clement Soldier married a young lady who was a student, and is considered one of the most progressive men on the reservation. He is at present doing clerical work in the Agent's office."

I knew every one of these, when as boys and young men they made their start into civilization from the condition of purely camp Indians, living in tepees, unable to speak or understand English, brought up on wild meats, berries and roots, thinking only of the chase, the dance and war. The great change was wrought quite entirely through a trip out from the reservation among the whites, that lasted some years, during which they were under civilized educational and industrial training. Had their education and industrial training been carried further, and their civilized environment been prolonged even to permanence, the results would surely have been a complete transformation. Practically the same presentation of results, from the same cause, can be shown in every Indian tribe in the United States.

Carlos Montezuma is a full-blooded Apache Indian. When he was thirteen years old he was captured by the Pimas and brought to their camps, where he was offered for sale, a horse being the price asked. A traveling photographer, who happened to be in the Pima camp taking photographs, became interested in the boy and offered $30, the price of a horse, which the Indians accepted. He brought the boy East, and had him with him in his gallery in Brooklyn, Boston and Chicago. He sent him to the public schools, and finally, through the interest of a lady of means, he entered the Illinois University. He developed special aptitude for chemistry, and when he graduated a place was found for him in a drug store near the Chicago Medical College, where, as a clerk, he supported himself and earned the means for carrying himself through a course in the college. He graduated in 1888, and under the advice of friends, put out his sign in Chicago. After a year or so he yielded to the request of the Commissioner of Indian Affairs, and served most creditably for several years as an Agency and school physician under the Indian Bureau East and West, but returned to Chicago, and for a dozen or more years has been in successful practice in that great city. He knows nothing of his native Apache language, nor is there a trace of Apache superstition or custom to be found in him.

CIVILIZATION IS ONLY A HABIT.

One of the principal men of the Comanches is the son of a white mother and a Comanche father. His mother belonged to one of the first families of Texas, and lived in the central part of the State. The Comanches, in one of their raids, captured her when she was about fifteen years old. She became the wife of a young Comanche of some importance, had a number of children, forgot her mother tongue, and was lost to her people for many years. Finally she was discovered and induced to return to her childhood's home. She spoke only Comanche. Her habits and dress were entirely those of the Comanche Indians. Her relatives were very kind, and dressed her in the garb of civilization and treated her with every mark of affection. She was not long with them before she showed discontent, and finally disappeared, and alone traveled the hundreds of miles between her relatives' Texas home and the Comanche camps, to be with her husband and children. These facts I had from Horace P. Jones, a most reliable white man, who lived with the Comanche Indians from 1856 until his death in the late eighties. I have known the son forty years.

Among the first students brought to an Eastern school in October, 1879, was a light complexioned boy about sixteen years old, to whom the school people gave the name of Stephen. He was in blanket, leggings and moccasins. His hair was long and matted. He was as dirty and as much covered with vermin as any in the party. He spoke no word of English, but could speak the Indian language with as much fluency as the others. His teacher found, as he developed, that while he had a good mind he learned English with less readiness and made slower progress than many of the Indian boys who came with the same party and under like circumstances. When he was presented at the Agency as a pupil, inquiry developed that his father and mother were white people, and while crossing the plains to California their party had been attacked by Indians. His father was killed, and his mother captured. Stephen was born just after this event. His mother married an Indian, by whom she had other children. When these facts became known, a message was sent to the far away camp, asking her to come to the Agency to see the School Agent. She sent word back that she was an Indian now, and did not want to come into the Agency, but that she wanted her white boy to become educated with his own race. I have known scores of like cases.

SAVAGERY IS ONLY A HABIT.

America stands preëminent for the unity of races and the personal freedom of the individual, and it has established beyond peradventure that the real problems are methods and systems, and not man himself.

The assimilating and utilizing of all people within its jurisdiction is both the prerogative and duty of the nation, because national preservation requires it. To leave or to build any race or class as special or alien to the general welfare, hinders growth, multiplies expense and fosters anxiety and violence.

The duty resting upon me in the opportunity offered by your invitation, is to help you see as plainly as I do, that when treated like other folks, there really is no problem in the Indian himself, and that the difficulties we contend with in our efforts to unify and utilize him as a man and a citizen are of our own creation. Long experience with Indians confirms my text. The Indian is rather raw material in the forest, mountain and plain to be brought into and put through the proper refining influences of our civilization mills of to-day, wrought into shape and then sent to work on the great oceans of our industry and thrift.

History, our own experience and common sense, ought to have shown us decades ago that if we really wanted to civilize the Indians, we were pursuing a course designed to exactly frustrate our wishes.

Our success in Americanizing, if not entirely assimilating, black savages forty times more numerous now in America than our Indians, and our success in reaching happy results on the same line with foreigners from almost every land, and our failure after centuries to accomplish any material like results with the Indians ought to have led us to hunt the reason and adopt different methods long ago. Bringing Negroes from many tribes in Africa here and scattering them, even under the heel of slavery, ended their gibberish and gave them the richest language in the world, and made them a valuable part of our industrial population, and where there have been wide individual opportunities they have risen to respectable place and prosperity. With all their limitations, they are ten millions of rapidly increasing people, a nation in numbers, saved by the brotherhood of contact to usefulness and civilization. On the other hand, the very existence of the tribesmen from whence they were taken hangs in a balance because of the disabilities of their ignorance and degeneracy, due solely to the lack of brotherhood and the greed of civilized countries.

Encouraging foreigners of all lands to come and settle among us, in every instance where we have avoided segregating them in separate and large communities, has led them to abandon their past and become thoroughly American. On the contrary, where we have allowed foreigners to settle in large communities, the process of Americanizing has been hindered and in some instances almost entirely prevented.

In some localities in Pennsylvania we have German communities so compact that the third and fourth generation of residence has not given them our language. On the other hand, there are innumerable instances of matured Germans, who having separated from their German surroundings and immersed themselves in American surroundings, have lost all German trace, even to the accent.

The first great barrier to be thrown down in all work of assimilating and unifying our diverse population, is the barrier of language.

The process of giving the American language to foreigners who are willing to disperse among us, is so simple and effective that it gives us no concern ; scarcely, in fact, attracts attention.

No school is needed, no special teacher or organized effort. It simply does itself.

Is there not a lesson in this ?

We organize and force upon the Indian through our sustaining of the tribal relation by the segregating system of Indian reservations, a condition exactly the reverse of this, calculated to not only discourage but to entirely prevent his obtaining a usable knowledge of the American language, life and industries except in the impractical way we choose to dispense to him by theoretical schools established in his communities.

The foreigner, while getting the language through freedom of association, continues also to obey the decree of the Almighty — "In the sweat of his face shall man eat bread" — and thus without school or special teaching imbibes and absorbs all the vital principles of our America, and accommodates and unifies himself with them. On the contrary, all our work for Indians, including Indian schools on the reservations, is weak and inefficient because lacking in the essential elements of practical experience, association and competition. It is, therefore, not calculated to beget in the Indian the courage and ability to struggle, but rather educates in him a fear of these conditions and makes him shrink from the very competition necessary to enable him to reach his place as an independent man and citizen.

Suppose we should take twenty thousand of the assisted emigrants landing on our shores, belonging to any nation under the sun — England, Scotland, Arabia, Hungary, Italy or Africa — and put them on a reservation in South Dakota, as we have the twenty thousand Sioux, who have been there under our care for four decades, place over them agents with a few employees and establish among them schools for their own children only, make them amenable to a Bureau in Washington to the extent that they cannot leave the reservation without its consent, issue rations and annuities to them and treat them as though they were a separate nation, would they ever develop into capable Americans? Would not these very conditions hold them to their past?

Why then is it worth while for us to expect a contrary result from Indians so placed?

Are not the conditions we have forced upon and maintained among and about the Indians entirely the cause for their non-acceptance of our civilization? Is the fault at all theirs?

We make a great pretense of helping, and do give inordinate sums of money in purchase of land and for their support, their schools, for their agricultural and other necessary development in preparation for citizenship, but does it accomplish the purpose?

None of our Indian tribes, and very few individual Indians, have been favored with anything like the same opportunities to acquire the true spirit of America, which we at once freely give to foreign emigrants.

Many individual Indians have risen far above what their privileges would imply, and all Indians within my knowledge are fully up to their opportunities.

I can therefore safely say, "The Indian is No Problem."

The United States Government has expended in material, machinery and instruction in agriculture for the Sioux Indians a sum that will exceed many times in value the amount that could have been realized for all they have ever raised, due entirely to improper and inefficient control and meagre instruction remote from practical examples.

In twenty-six years we paid forty million dollars for support of the Sioux, and almost as much more for lands purchased from them, and Army expenses to keep them on their reservations.

Suppose one-fourth of this vast sum had been expended in the proper education of their children in the surroundings of our American thrift and in encouraging and helping them, old and young, to immigrate into and distribute and make themselves useful throughout our communities, can there be any doubt that the Sioux would now be English-speaking, intelligent, useful, self-supporting citizens?

Of the many demoralizing influences we have devised for our Indians, we can count upon money annuities and the payment to them per capita of large sums for lands ceded by them as among the most fruitful and disastrous.

This system was adopted early in our intercourse with them, and has grown in volume through the years, until now it is not uncommon to pay to one tribe millions of dollars.

In 1722 the lower half of Berkshire County, Massachusetts, was purchased from the Stockbridge Indians for £460, three barrels of cider and thirty quarts of rum, and the Stockbridges were moved over into the wilds of central New York, and when our people closed in upon them in their new home, they were again bought out and sent to Wisconsin.

In 1894 a piece of land along the northern border of the Indian Territory, called the Cherokee Strip, was purchased from the Cherokee Indians for eight million dollars. As time goes on you see it pays more and more, in money, to be an Indian.

Of the tribes which receive large regular annual payments, the Osages are a glaring example.

The sale of their lands in Kansas under a treaty agreement brought them about nine millions of dollars in the United States Treasury, the interest of which at five per cent. has been paid to them per capita for a third of a century.

When the treaty was made they numbered over 4200; to-day they number a bare 1500.

The payment of this money has stifled all energy and industry and been the fruitful cause of their destruction.

An agent who had charge of them at an early day and then again years afterwards, told me that notwithstanding the law and all the protection he could give, the amount of whiskey consumed by them in two weeks during his later administration was more than equal to that which they got in a whole year in his first administration.

The dissipation, idleness, disease and crime which has thus reduced this tribe, composed originally of fine specimens of physical manhood, capable of greatest endurance, are all the direct result of our grossly injudicious system and mistaken liberality.

The year their treaty was made, General Sheridan engaged a party of Osages as scouts and couriers, and secured from them a service of 75 to 80 miles per day on foot across the country.

It is doubtful if a single Osage could be found able now to accomplish any such feat.

Money never has and never can settle the obligation resting upon us toward this Indian brother of ours. What he has always needed, and needs now, is fraternity and its privileges.

We forcibly made ourselves our Indian "brother's keeper," and he always has had far more right to rise against us in judgment, and greater cause to condemn us, than the Negro ever had.

General Milroy, Agent for the Miamis and Pottowatamies in Indiana, in his annual report in 1847 gave a picture of the drunkenness, debauchery and crime produced by the payment of the annuity he had made that year to those Indians, and statistics to show how by the hundreds, year after year, they had murdered each other when under the influence of drink procured from designing white men with the money we gave.

He stated that probably in the history of the human family there was no other parallel case where a whole nation had actually destroyed itself by assassination.

General Milroy's picture is applicable to-day and bears on many tribes.

We have not only turned our own hands against them to destroy them with violence, but we have led them and continue to lead them, to destroy themselves.

Inviting the Indians to always look to the Government for support instead of continuing to rely upon their own right arm, is another of the great evils of the system.

Be the amount ever so small, the receiving of it is to them the greatest of all the events of the year.

The payment of $4.00 or $5.00 per capita brings a whole tribe together at the Agency, bag and baggage, men, women and children, tepees, dogs and ponies, to the entire neglect of their farm patches. Immediately they get their money they turn it over to the authorized trader, who, taking advantage of his exclusive privileges and their vanity and necessities, teaches improvidence through trusting them to the amount of the payment, and too often with goods at inordinate prices. The stubborn fact remains that we have scarcely any Indians in the United States free from Bureau control, and the evils named, and many others consequent upon our Bureau system of sustaining and forwarding tribal conditions, are in the way of any complete, individual development and growth into real citizenship.

The 5000 Indians in the great State of New York live on reservations under the supervision of the Indian Agent, and by this very fact are helped to avoid association and competition with us, and to reject the use of our systems of law, schools and development.

The arguments and devices we resort to, to keep up these tribal organizations, are unworthy of our civilization. Any careful examination into these conditions will prove that the Indian is to be exonerated from being dependent and worthless, and that we are entirely the guilty cause of his slow progress in civilization.

The early death of the "Freedman's Bureau," with its "forty acres and a mule," was an infinite blessing to the Negro himself and to the country as well.

Far better for the Indians had they never been placed under such a Bureau system.

Then the great law of necessity and self-preservation would have led the individual Indian to find his true place, and his real emancipation would have been speedily consummated.

What I contend for in part is that the small number of Indians in the United States, especially the Indian children, shall have privileges beyond the tribe, the privilege of seeing and learning what the United States does for other men, and may do for them.

Reservations for Indians mean now, and always have meant, reservation from experiences and from opportunities for right education and civilized industrial development.

The policy is wrong.

We should not only be willing but helpful to get the Indians, and especially the children, out into the active life of the nation. Help them less in tribal education and help them more to come into individual relations with our general industrial and educational systems.

We do not hesitate to take a million foreigners into our country in one year, and at once disperse and citizenize them. We count it righteousness to invite and persuade the boys and girls of all countries to abandon their homes and languages and come here to become a very part of our population.

We give opportunity for the boys and girls in the slums of New York to escape from their surroundings of ignorance and vice, and enter the well-to-do homes of our people all over the country.

A recent Governor of Alaska as a boy went out from the slums of New York to a family in Indiana, who took him into their good home, educated and trained him into proper manhood, and he became what he is. A distinguished member of Congress, now chairman of one of its most important committees, had the same experience.

Left in the slums of New York they would probably never have reached any such usefulness or distinction.

Taken into better influences, they become great and good men.

We compelled the Negro, and invite the Huns, the Italians and every one else, to come and live with us. Why hesitate to be equally generous and invite the Indians to full enjoyment of the same chances?

We have only 270,000 Indians outside of Alaska. If instead of forcibly holding them together on reservations and in tribes, our every influence helped them to opportunities away from the reservations, their interests and ours would soon be assimilated, and that would be the end.

"The contact of peoples is the best of all education." Thousands of instances prove that Indians, by association with our own people, become in all respects like them — in thought, speech and usefulness.

Schools exclusively for Indians are just as well calculated to build and keep the Indians intact as Indians, as church schools are to build and keep churches intact.

Under Federal principles we have established the public school system, where people of all races may become unified in every way and loyal to the Government.

We do not separate the people of each nationality into schools exclusively for themselves, but we provide that the youth of all our people may go into all schools.

We shall not succeed in Americanizing the Indian until we work on him in exactly the same way. Even if abundant schools, but for Indians only, are established remote from reservations in civilized surroundings, if the principle of sending them out into families and into the public schools is left out, the result is failure, even though such schools are established in the centres of our most intelligent, industrious and friendly population, and though such schools are filled with students from many tribes.

Purely Indian schools say to the Indians: —

"You are Indians and must remain Indians; you are not of the nation and we do not want you in the nation."

Before I leave this part of my subject, I am sorry to feel impelled to lay before you the facts as I have been forced to look at them, of another influence that has claimed credit and always has been and is now very dictatorial in Indian affairs, and that is the missionary as a citizenizing influence among the Indians.

The missionary goes to the Indian; he learns the language; he associates with him; he makes the Indian feel he is friendly and has great desire to help him; he even teaches the Indian English; but the fruits of his labor have been to strengthen and encourage the Indians to remain separate peoples.

Those Indians who desire to become civilized and to live like white men, who would with little encouragement go out into our communities, are the first to join the missionary forces. They become his lieutenants to gather in others.

The missionary must necessarily hold on to every help he can get in order to forward his scheme and plans so that he may make a good report to his church, and in order to enlarge his work and make it a success he must keep his community together.

Consequently, many who would care to get out into the nation and learn from actual experience what it is to be civilized, what is the full length and breadth and height and depth of our civilization, are led to stay and help the missionary.

The operation of these tribalizing missionary systems has been disastrous to any individual escape from the tribe, has vastly and unnecessarily prolonged the solution of the question, and has needlessly cost the charitable people of this country large sums of money, to say nothing of the added cost to the Government, through prolonged supervision and the delay in accomplishing their civilization and citizenship.

If, as sometimes happens, the missionary kindly consents to let, or helps one go out and get these experiences, it is only for the purpose of making him a preacher or a teacher or help of some kind, and such an one must, as soon as he is fitted, and much sooner in most cases, return to the tribe and help the missionary to tribalize his people.

The Indian who goes out has charitable aid through his school course, forfeits his liberty and is owned by the missionary.

In an experience of forty years I have known very few missionaries to heartily aid or advocate the disintegration of the tribes and the giving of individual Indians rights and opportunities among civilized people.

The missionaries dictate what our policy shall be with the tribes, and their dictations are always along the lines of their colonies and church interests, never towards citizenship, and the Government must guage its actions to suit the purposes of the missionary, or else the missionary influences are exerted to defeat the purposes of the Government.

Thus the Government in paying large sums of money to churches to carry on schools among Indians only builds hindrances to Indian citizenship.

Twenty-six years ago, under the orders of the Department, I went West after children for an Eastern Indian school. I found communities aggregating 11,000 Indians. They were not nomads; they were village dwellers, agriculturalists, stock raisers, and their communities were among the oldest within the limits of the United States.

They had been under the influence of a church for 250 years, and at this time the power of that church over them in all their affairs was absolute. They paid taxes and tithes to it alone, and yet there was not one single Indian in the whole 11,000 that could either read or write in English or any other language.

When I brought up the subject of education, I was met with the strongest possible opposition, and confronted with the fact that the Indians had been commanded by the officials of that church not to obey the Government and send their children to school, to learn the language and ways of the country in which they lived.

We make our greatest mistake in feeding our civilization to the Indians, instead of feeding the Indians to our civilization.

America has different customs and civilization from Germany. What would be the result of an attempt to plant American customs and civilization among Germans in Germany, demanding that they shall become thoroughly American before we admit them to the country?

It is equally a mistake to think that the Indian is born a savage. He is born a blank like all the rest of us. Left in the surroundings of savagery, he grows to possess a savage language, superstition and life.

We, left in the surroundings of civilization, grow to possess a civilized language, life and purpose. Transfer youth from our highest civilized families to savage surroundings, and they will grow to possess a savage language, superstition and habit. Transfer the savage born youth to the surroundings of civilization, and they will come to possess a civilized language and habit.

These results are inevitable and established over and over again beyond all question, and it is also well established that those advanced in life, even to maturity, of either class, soon lose the already acquired qualities belonging to the side of their birth, and gradually take on those of the side to which they have been transferred.

As we have taken into our national family ten millions of Negroes, and as we receive foreigners at the rate of a million a year, and assimilate them, it would seem that the time may have arrived when we can very properly make at least the attempt to assimilate our 270,000 Indians, using these same potent methods, and see if that will not end this vexed question, and end the Indian as a curiosity, where he occupies so much more space than he is entitled to, either by numbers or worth.

No evidence is wanting to show that the Indian can become a capable and willing factor in our industries, if he has the chance. What we need is administration which will give him that chance.

The highest purpose of all Indian schools ought to be to prepare the young Indian to enter the public and other schools cf the country, and immediately he is so prepared, for his own good and the good of the country, he should be forwarded into these other schools, there to temper, test and stimulate his brains and muscles into the capacity he needs for his struggle to secure the good things of life in inevitable competition with all our other people.

The missionary can, if he will, do far greater service in helping the Indian than he has done, but it will only be by practicing the reality of the brotherhood he preaches.

As his work is to lift into the higher life the people whom he serves, he must not, under any pretence, give the lie to what he preaches by discouraging any individual Indian from going into higher and better surroundings; but on the contrary, his duty is to encourage and help the Indian to do that. If he fails in thus helping and encouraging the Indian, he is false to his own teaching and stands in the way of progress.

Investigation proves that no Indians within the limits of the United States have acquired any sort of capacity to meet and cope with the whites in civilized pursuits, who did not gain that ability by going among the whites and out from the tribes, and that many have gained this ability by so going out. Theorizing citizenship ability into a whole body of people segregated away from citizens is a slow operation.

The Indians can never come to understand or use American citizenship theoretically taught to them on Indian reservations. *They must get into the swim of American citizenship*, and like ourselves feel the touch of it day after day, until like us they become saturated with the spirit of it, and thus like us become equal to it.

When, where and why has there ever been any problem about the Indians themselves?

* * * *

A number of questions followed the completion of this paper. Mr. John B. Rhodes asked, "Do the graduates and other students, going out from such schools as Carlisle, profit by their education, or do they degenerate and go back to their original condition?" General Pratt invited attention to the beginning of his address, giving examples after a test of a quarter of a century, and said that the question was the most common one asked about educated Indians. The doubt such inquiries indicated was caused by the publication of many false stories about alleged returned students, reinforced by the official vagaries and unfounded allegations of a recent Commissioner of Indian Affairs. He said he had a dozen Sunday newspaper stories alleging criminal conduct and worthlessness on the part of alleged returned students, and not one of them was true in any sense. He then read from the Annual Government Report of the Commissioner of Indian Affairs for 1898, that the Indian Office had made investigation that year covering the worth of all returned students, which showed that the character and usefulness of 76 per cent. of them compared favorably with educated white boys and girls under similar conditions; that their actions after they had returned to the reservations showed that they had gained capability for and practiced a career of usefulness similar to that of the average educated white man.

He read another extract from the Annual Report of the Indian Office for 1901, showing that the Office had again made a more thorough investigation and found that the proportion of "excellent" in character, ability and usefulness had risen to 10 per cent., and of the remainder those rated as "good" had increased to 76 per cent., "showing that in all respects the useful effect of non-reservation education upon young Indians was fully equal to the influences of good education upon the young of the white race." He suggested that those interested read the Indian Office Reports for 1898 and 1901 on this subject.

Mr. Walter H. Corkran asked, "Do the Indians themselves want to become civilized?" The General replied, "The Indians have been held aloof from civilization, and therefore have had no fair chance to determine what they wanted in regard to it;" that all his experience showed they did want our civilization, whenever they came to an understanding of it, but that it was not a question as to their wishes in the matter. The Government had assumed guardianship over them and their affairs and was allotting them lands individually, thereby clothing them with citizenship.

Successful holding and use of their lands and of themselves required that they should become civilized, educated and trained to the ability that would enable them to hold their own property and use it in competition with other citizens.

The General was asked what he thought of the influence of the annual conferences at Lake Mohonk upon the solution of our Indian troubles. He stated that the conference at Lake Mohonk began as an annual meeting of the Board of Indian Commissioners; that the Board of Indian Commissioners was instituted by General Grant when he became President; that Congress had authorized the creation of a Board of "not to exceed ten men, eminent for intelligence and philanthropy," who would look into all Indian matters, visit the Indians and the Agencies, and coöperate with the Commissioner of Indian Affairs; that the books, papers and purchases throughout the Indian service, and everything connected with Indian management, was open to their inspection and suggestion. General Grant's idea seemed to be that through such a Board there would grow up intelligent interest for the Indians throughout the country, and that greater integrity of administration and a more righteous action in regard to the Indians would result. General Pratt said that during the first years of the Board, the members, individually or in committees, did visit the Indians, even the wildest of them, and did give to the President and the Indian management intelligent and very great help, hindering wrong and arousing much interest among our people; but for twenty-five years or more the Board had met annually at Lake Mohonk to enjoy the fine hospitality of that delectable resort; that the members now seldom, if ever, visit the Indians or their reservations, or get into any real touch with Indian management; that for years they had mostly turned the duties, for which the Board was instituted, over to self-constituted and inequitable associations, inert to either protect the Indians or lead them into higher life; that the conference was not an open parliament, as he had experienced when present. He said that if the original intention of General Grant had been carried out, and the members of the Board had continued to visit the Indians and take a personal interest in their welfare, very much greater results for good would have been accomplished. He advised the inquirer to get the Report of the Commissioner of Indian Affairs for 1869, and read what the first Board did, and he would see what General Grant intended. General Grant in his first inaugural said, "I will favor any course toward them which tends to their civilization and ultimate citizenship," and worked to that end. For the past four years this policy has been reversed, and the voice of the Administration has said to the Indians, "Stick to your past, build on that, remain tribal." If you were an Indian, subject to such variable control, what would you think? General Pratt said fine speeches, lofty resolutions, and even immaculate laws, are only useful when they become energizing forces to accomplish things; that the vastly greater need of the Indian has always been the kind of friends who would take him by the hand and lead him out from the deadening seclusions of ignorance and dearth of opportunity in the tribes on the reservations, and find him welcome in the best experiences of our American life, where he may have a square chance to make of himself a useful citizen. What a blessing it would have been if the men who made the speeches and the resolutions had taken hold themselves and given this indispensable help, and also stood firmly by and demanded a square deal for those who were giving that kind of help.

He was asked if the Indian has the same difficulty socially as the Negro has, whether there was the same prejudice against his presence in the social life of the people. The General replied he had not found that kind of prejudice; that young Indians were welcomed in every school and college in the land; that it was not a question of race, but a question of preparation; that if the Indian was fitted for recognition, there were no doors closed to him, so far as his experience went; that he knew of many Indians who had abandoned tribal life and enjoyed all the recognition socially, to which they were entitled by their education and conduct.

The General said further that the Indian is one of the most reasonable of men to develop, govern and guide into right channels; that he had dealt with white men largely, and with Negroes also; that the Indian in contact with men of intelligence, who desire his highest good and who give give him fair reasons why he should take on intelligence and usefulness, is perfectly amenable, and readily complies. He spoke of a President of the United States, who had met an Indian out West, living in a tepee, and when later the Indian called at the White House, dressed in civilized garb, the President said to him, "I like to see you in your Indian dress better than the way you are dressed now." The General said that the influence of such views from so high an authority could not help but be detrimental to the Indians' progress in civilization, especially when enforced as they have been in recent years as a special feature of Indian management. He condemned the new Indian policy, and said it was unAmerican, a reaction against progress, and enhances Bureau control more than the civilization of the Indian people; that the low education, weak ability and inexperience it fosters continues the Indians an easy prey for the depredators fattening upon their estates.

There were other questions asked, but these were the most material.

A FAMILY OF PROJECTILE PARABOLAS.

BY HAROLD C. BARKER, PH. D.

In the following discussion of an interesting group of mathematically and physically related curves, my aim is simply to present some more or less well known facts in a brief and connected manner.

Let us consider: —

I. The equation of the family of parabolas that are the paths, in a medium offering no resistance, of projectiles with a given speed of projection in a given vertical plane.
II. Their common directrix.
III. The locus of their vertices.
IV. The locus of their foci.
V. The loci of their latus rectum extremities.
VI. The envelope of the family.

I. The equation of the path of a projectile in an unresisting medium can be found as follows: Taking horizontal and vertical coördinate axes in the plane of motion, and the origin at the point of projection, the coördinates of the projectile at any time t after projection are given by

$$x = V \cos\alpha \; t \qquad\qquad y = V \sin\alpha \; t - \frac{gt^2}{2}$$

where V is the speed of projection, α the angle of projection measured from the x-axis, and g represents the magnitude of gravitational acceleration.

Eliminating t between these equations, we have

$$y = x \tan\alpha - \frac{gx^2}{2\,V^2 \cos^2\alpha} \quad \ldots\ldots\ldots \; (1)$$

which is the equation of the path, recognizable as a parabola with its axis vertical.

Now, if in this equation V be constant, while a may assume all real values, we have the equation common to the projectiles in a given plane, for which the speed of projection is the same, the difference between the several curves depending on the angle of projection only.

II. It can now be shown that these parabolas have a common directrix. Recalling that in any parabola the distance between the vertex and directrix is one-fourth of the latus rectum, we proceed to determine the ordinate of the vertex and the value of the latus rectum. The former can be found conveniently by determining the abscissa of the vertex as a critical point; then, by substituting this value in the equation of the curve, the corresponding ordinate will be obtained. The procedure is

$$\frac{dy}{dx} = \tan a - \frac{gx}{V^2\cos^2 a} = 0$$

Whence, $$x = \frac{V^2\sin a\cos a}{g}$$

And, substituting,

$$y = \frac{V^2\sin^2 a}{g} - \frac{V^2\sin^2 a}{2g} = \frac{V^2\sin^2 a}{2g}$$

This is the ordinate of the vertex. Now, from the equation of the parabola (1) the latus rectum is $\frac{2V^2\cos^2 a}{g}$

Therefore D, the directrix ordinate, is

$$D = \frac{V^2\sin^2 a}{2g} + \frac{V^2\cos^2 a}{2g} = \frac{V^2}{2g}$$

Thus D is independent of a, and the curves have a common directrix whose equation is $y = \frac{V^2}{2g}$

III. The equation of the locus of the vertices follows upon eliminating α between the expressions for abscissa and ordinate of the vertex. These are, as above

$$x = \frac{V^2 \sin\alpha \cos\alpha}{g} \quad \text{and} \quad y = \frac{V^2 \sin^2\alpha}{2g}$$

Or, conveniently, since $\dfrac{V^2}{2g} = D$

$$x = D\, 2\sin\alpha\cos\alpha \qquad y = D \sin^2\alpha$$

which can be put

$$x = D \sin 2\alpha \qquad y = \frac{D}{2}(1 - \cos 2\alpha)$$

whence

$$\frac{x^2}{D^2} = \sin^2 2\alpha \qquad \frac{\left(y - \frac{D}{2}\right)^2}{\left(\frac{D}{2}\right)^2} = \cos^2 2\alpha$$

and, adding

$$\frac{x^2}{D^2} + \frac{\left(y - \frac{D}{2}\right)^2}{\left(\frac{D}{2}\right)^2} = 1$$

Which is the equation of an ellipse, centre at $\left(0, \dfrac{D}{2}\right)$ semi-axes D, $\dfrac{D}{2}$

IV. Now, since in the parabola the vertex is midway between the focus and the directrix, the ordinate of the focus is given by subtracting one-fourth of the latus rectum from the vertex ordinate. That is, F, the ordinate of the focus, is

$$F = \frac{V^2\sin^2\alpha}{2g} - \frac{V^2\cos^2\alpha}{2g} = -\frac{V^2\cos 2\alpha}{2g}$$

or

$$F = -D\cos 2\alpha$$

Now, if we eliminate α between

$$y = -D\cos 2\alpha \qquad \text{and} \qquad x = D\sin 2\alpha$$

the latter being the expression for the abscissa of the focus as well as the vertex, since the axis of the parabola is vertical, we obtain the equation of the locus of foci.

Squaring and adding

$$x^2 + y^2 = D^2,$$

which is the equation of a circle, radius D, centre at origin.

V. The loci of latus rectum extremities are given by

$$y = F = -D\cos 2\alpha \qquad \text{and} \qquad x = D\sin 2\alpha \pm 2D\cos^2\alpha$$

the abscissæ of the two ends of the latus rectum being found by adding one-half of its length to, and by subtracting the same quantity from, the abscissa common to vertex and focus. We can successively write

$$x \mp 2D\cos^2\alpha = D\sin 2\alpha$$

$$x \mp D(1 + \cos 2\alpha) = D\sin 2\alpha$$

$$x \pm y \mp D = D\sin 2\alpha$$

which, with $y = -D\cos 2\alpha$, on squaring and adding, gives

$$(x \pm y \mp D)^2 + y^2 = D^2$$

By transferring the origin to $(\pm D, 0)$ and rotating the axes through $\frac{1}{2}\tan^{-1}(\mp 2)$, or about $\mp 31^\circ\ 43'$, this becomes

$$\frac{x^2}{\frac{(3 + \sqrt{5})\,D^2}{2}} + \frac{y^2}{\frac{(3 - \sqrt{5})\,D^2}{2}} = 1$$

From which the loci are evidently a pair of ellipses, centres at (D, 0) and (—D, 0), semi-axes

$$D\sqrt{\frac{(3+\sqrt{5})}{2}} \quad \text{and} \quad D\sqrt{\frac{(3-\sqrt{5})}{2}}$$

VI. The equation of the envelope is got without any difficulty by eliminating α between the equation (1) of the family, and the partial derivative of that expression with respect to α.

Equation (1) may be put

$$y - x\tan\alpha + \frac{x^2\sec^2\alpha}{4D} = 0$$

Taking the partial derivative with respect to α,

$$-x\sec^2\alpha + \frac{x^2\sec^2\alpha\tan\alpha}{2D} = 0$$

Dividing through by $x\sec^2\alpha$,

$$\frac{x\tan\alpha}{2D} - 1 = 0$$

Whence $\tan\alpha = \frac{2D}{x}$ and $\sec^2\alpha = 1 + \frac{4D^2}{x^2}$

Substituting in (1),

$$y = 2D - \frac{x^2\left(1 + \frac{4D^2}{x^2}\right)}{4D}$$

or

$$x^2 = -4D(y - D)$$

and this is the equation of a parabola with vertical axis, vertex at (0, D), focus at (0, 0), and latus rectum 4D.

Summarizing the results, we have

I. Equation of family:

$$y = x \tan\alpha - \frac{gx^2}{2V^2 \cos^2\alpha}$$

II. Equation of directrix:

$$y = \frac{V^2}{2g} = D$$

III. Equation of locus of vertices:

$$\frac{x^2}{D^2} + \frac{\left(y - \frac{D}{2}\right)^2}{\left(\frac{D}{2}\right)^2} = 1$$

IV. Equation of locus of foci:

$$x^2 + y^2 = D^2$$

V. Equation of loci of latus rectum extremities:

$$(x \pm y \mp D)^2 + y^2 = D^2$$

VI. Equation of envelope:

$$x^2 = -4D(y - D)$$

Referring now to the accompanying graph, it will be seen that those members of the family characterized by $D = 64$ (that is, $V = 64$, if $g = 32$) for which α has the values 0 and multiples of 15° have been figured. Various matters of detail might be mentioned, as, for instance, that when $\alpha = 45°$ the horizontal range is maximum; also, that when $\alpha = 90°$ (vertical projection) the parabola is reduced to a pair of coincident straight lines, with focus and vertex at a common point $(0, D)$ on the directrix; and thus the directrix ordinate is the greatest height reached when a body is thrown vertically upwards with the given speed. These matters can of course be shown analytically with the greatest ease.

It is to be noted that values of a in the third and fourth quadrants merely repeat curves given by angles in the first and second quadrants respectively; a fact at once evident on inspection of the equation.

It will now be easy to remove the restriction of a given vertical plane of projection, and consider the corresponding loci if the paths lie in any vertical plane. Thus, the locus of vertices becomes an ellipsoid of revolution, the locus of foci a sphere, etc., the surfaces being simply those generated by revolution of the former loci about the y-axis.

To guide the eye in following the graph, the latus rectum, and the part of the axis between focus and vertex, of each parabola, have been shown; also, the axes of the inclined ellipses (loci of latus rectum extremities). In addition, the Roman numerals have been used as in the text.

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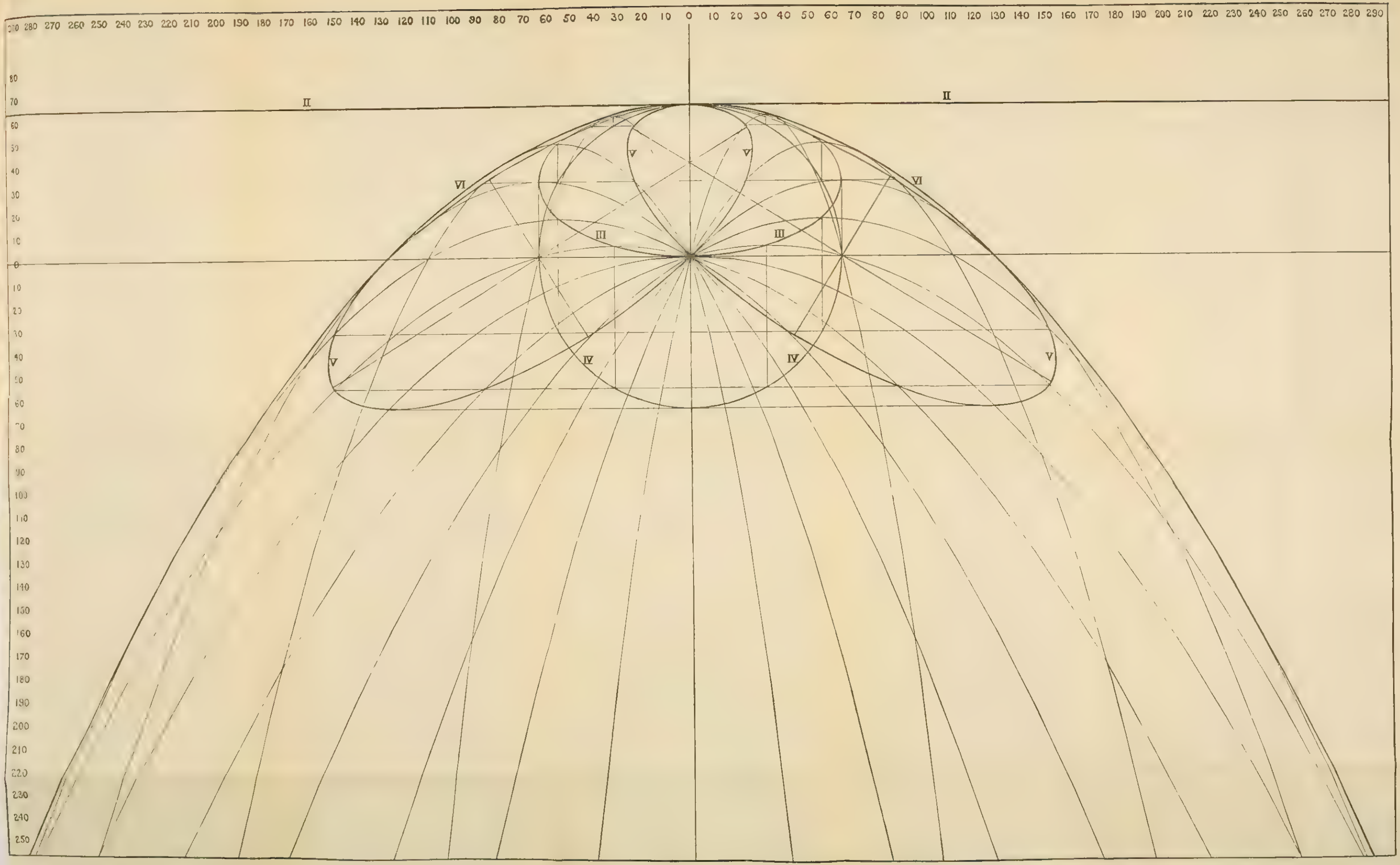

PROJECTILE PARABOLAS.

VARIATION OF ACCENT IN ENGLISH WORDS.

BY HENRY L. BROOMALL.

In a previous article in this journal* it was suggested, perhaps shown, that the common error of speech conforms to the same laws of linguistic development that produce the correct form of language, that the persistent error of to-day becomes the correct form of to-morrow, that the disappearing error of to-day was the correct form of yesterday, and that a living language is always changing as the community using it changes. The illustrations of this proposition, adduced in that paper, were acknowledged errors of speech, condemned by all good speakers of English. Such errors are not mentioned by grammarian or lexicographer except for flat condemnation. The purpose of the present paper is to examine the lexicographer, the assumed authority upon pronunciation, to note how far, in his attempt to represent good English usage, he acknowledges that there are two or more proper accentuations of a word, and to show that the variant pronunciations thus authorized, and the errors of pronunciation condemned by this authority, are products of the same linguistic laws. In short, the variant pronunciation, allowed by the dictionary, is either a survival of an old pronunciation not yet become obsolete, or an anticipant of a future pronunciation not yet acknowledged as solely correct. The variant pronunciation of a word denotes a condition of instability, and instability necessitates change — and as far as we find the lexicographer authorizing a variant we gain his unwilling testimony to the standing and significance of many pronunciations he ignores or formally condemns. If he says "*abdo'men* or *ab'domen*," why not "*inqui'ry* or *in'quiry?*" Yet he does not admit *in'quiry* as a variant. But such pronunciation is coming by linguistic laws, just as *in'jury* has come from

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* "The Significance of Errors in Speech," Proceedings of the Delaware County Institute of Science, Volume I, page 30.

inju'ry and *his'tory* from *histo'ry*. A preference is usually indicated in the dictionary by placing the supposed better pronunciation before the other. The lexicographer, in giving "*abdo'men* or *ab'domen*" indicates, by placing it first, that he prefers *abdo'men*, the older, classically derived pronunciation, founded upon a Latin long *o*, and therefore accented. His predecessors admitted only *abdo'men*; he is now forced to acknowledge *ab'domen* also; his successors may give simply *ab'domen*, just as he already gives only *in'jury* and *his'tory*. These changes of preference in variant pronunciations, traced in successive dictionaries, would show the gradual predominance of popular forms, such as are continually changing our own old words and forcing new words to accommodate themselves to English phonetic laws. But the present investigation is of a narrower scope. The specimens to be considered are those of variant accentuation acknowledged by the lexicographer as simultaneously extant. Any lexicographic authority would suffice for this purpose, and the Century is selected for our consideration because it is both scholarly and popular.

In the Century Dictionary two different pronunciations are given to 2234 words. This count includes derivatives as well as originals. Thus, where "*deco'rous* or *dec'orous*" is authorized, and also "*deco'rously* or *dec'orously*," the adverb is counted as an additional case of variant pronunciation. Derivatives and originals do not always suffer the same uncertainty of pronunciation, and therefore, where it does occur, it should be counted. Again, where two different spellings, either causing or accompanying two correspondingly different pronunciations, seem to represent an incipient differentiation of meaning, the forms are not strictly one word and are not counted as instances of variant pronunciation for our present purpose. Thus *thresh* and *thrash*, although etymologically the same word, are not counted because they are now receiving a difference of application, since we *thresh* wheat and *thrash* persons. The development, in such a case, has passed the point of variant pronunciation of a word and reached that of two words differentiating from one.

Of these 2234 words, 1020 vary in consonant sounds, 818 in vowel sounds, and 396 in syllabic accent. Some words, however, vary in more than one characteristic, such as *halfpenny*, where the *a* is *ă* when the *f* is heard and *ā* when the *f* is silent. This specimen might therefore be counted as variant in consonant or in vowel sound, or both, and in this enumeration such examples are counted as belonging to the particular variation which seems to the writer the more important. This personal element in the statistics, it is hoped, is not large enough to affect the conclusions to be drawn from them.

These figures are prima facie significant. They indicate that the greatest current instability of English pronunciation is in consonants, that the instability of vowels is about a fifth less, and that the instability of accent is less than a sixth of the whole. These relations, however, must be corrected by the fact that a particular consonant or vowel of frequent occurrence may be now vacillating in pronunciation, and thus inordinately increase the number of specimens of that characteristic. Thus *t* when uttered before English long *u* tends to become palatalized. Hence, *nature* (*t* varying between *ty* and *ch*) with eight derivatives, and *intellectual*, with nine, count large in these totals; in fact, this variant *t* constitutes more than half the consonantal variants.

Though variants in syllabic accent form but a sixth of the variant pronunciations authorized by the lexicographer, yet they are particularly illustrative of the present purpose because the stress on one of the syllables of an English word is more characteristic of it than some of its vowel or consonant sounds. Thus, if the speaker says "*particu'larly*" he would hardly be understood, but if he say — as he often does — "*p'tic'lrly*" he is understood, because so much of the significance of the word is on the accentuation of the syllable *tic*.

The tonic accent of an English word falls upon the syllable felt by the speaker to be chiefly significant. This law is so fundamental that it may temporarily change the syllabic accent where the significance of contrast or antithesis is emphatic, as in "this in'creases and that de'creases," although either word used alone would have the accent on the second syllable. Again, a root or stem syllable, now of little if any significance in itself and used only in composition, may retain this accent because the syllables around it are recognized as prefixes and suffixes. Thus, no modern English speaker thinks of the syllable *gin* as significant, yet in *beginning* he retains the accent on that syllable because *be* is a prefix and *ing* a suffix.

Where the word is polysyllabic, with no syllable significant as above set forth to hold or reject the accent, the English speaker tends to throw the accent toward the beginning of the word. He says *ab'domen* for *abdo'men*, with the dictionary's consent, and *in'quiry* for *inqui'ry* without it. The lexicographer knows that *in* in *inquiry* is a prefix and resists the change of accent. Logically enough, he wishes to preserve the accent on the significant stem — significant in the language from which the word is adopted. The speaker, however, does not recognize any particular syllable as stem or affix, and the phonetic law has full play, producing *in'quiry* just as it has already produced *in'jury* instead of *inju'ry*.

The shift of accent from one syllable to another is particularly observable in words adopted from another language where the general accentual law is different from English. With us, the adopted word is a whole, the syllables not separably significant, and if the word comes to play a valuable part in our speech, its naturalization with us is confirmed by its accordance with our accentual law. Thus *madame'* is French; *mad'am*(*e*) is English.

In our own hereditary Teutonic words the shift of accent taking place at any given period is limited to a few words because the conditions we have described have been operative so long that most of our words have undergone the change.

Thus *holy day*, in which *day* is the main and *holy* the subordinate modifying term, has become *holiday*. Though the parts *holi* and *day* may to a limited degree still be significant to the English speaker, yet the paramount accentual law is so strong that it operates upon the compound as soon as it becomes one word. On the other hand, the word *outside* is vacillating; both components are intelligible; sometimes we hear *out'side*, sometimes *outside'*; often the choice between the two seems merely euphonic or rhythmic. As an adverb or preposition, perhaps we may detect a tendency to preserve the accent on the syllable *side*, as in "*he stands outside'.*" As a noun or adjective, however, the accent tends toward the first syllable; we say "*the out'side of the house.*" This vacillation will adjust itself to phonetic law and significant needs, just how is beyond the scope of this article to predict. Here we simply note the vacillation as authorized by the lexicographer.

This purely phonetic tendency, however, is limited by the number and weight of the syllables thereby left unaccented. It is difficult to say *per'emptorily* and present speakers are introducing *peremp'torily*. This tendency is also subject to restraint where a word such as *record*, adopted from another language with the accent on the last syllable, comes to be used also as a noun. The verb often retains the old accent, as *record'*, while the noun follows the accentual tendency and shifts its accent, as *rec'ord*. This persistence of the accent at or toward the end of the verb probably represents a need for something to distinguish it from other parts of speech, a need only felt now when its peculiar inflections have almost entirely disappeared in English.*

In both *record'*, the verb, compared with *rec'ord*, the noun, and *outside'*, the adverb, compared with *out'side*, the noun, the law of the significant accent, as first above mentioned, asserts itself again and opposes the general phonetic tendency. In these cases the motive is grammatical instead of substantive significance. This contrast of accent to express a differentiation of grammatical use may become a very efficient apparatus in the English of the future.

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*See "Phonetic Characteristics of the English Verb," Proceedings of the Delaware County Institute of Science, Volume IV, page 23.

The statistics of variation in accent authorized by the lexicographer, 396 words, may be tabulated as follows: —

NUMBER OF SYLLABLES

Variation	2	3	4	5	6	7	
1–2	114	102	48	17			281
1–2–3		1	1				2
1–3		13	7	1			21
1–4				1			1
2–3		7	20	4	2	1	34
2–4				5			5
3–4				32	1		33
4–5				1	14		15
5–6						4	4
	114	123	76	61	17	5	396

In this table the number of syllables in the words is designated by the numeral at the top of the column. The order in the word of the particular syllables between which the dictionary acknowledges vacillation is designated at the left. The respective totals of these elements of the tabulation are at the bottom and to the right. Thus, the number 102 in the third column is the count of words of three syllables each with the accent authorized on either the first or second syllables, and it forms an item of the 123 total of trisyllables of variant accent and of the 281 total of variations between the first and second syllables of all the specimens.

This table shows that the most frequent variation of accent is in disyllables and trisyllables (respectively 114 and 123 – 237 out of 396) and between the first and second syllables

(281 out of 396). This preponderance of variants in first and second syllables is still greater when we note that the numbers in italic in the table represent derivative words whose accent is governed by their originals. Thus the trisyllable *cephalic* varies in accent between the first and second syllable, and this variation is extended to 47 derivatives of more than three syllables, such as *brachycephalic* and *microcephalic.*

According to the premises the variant accentuations authorized by the dictionary present the word so affected as undergoing a shift of syllabic accent. But the shift must have begun before the lexicographer dignified it as a variant. So may the old pronunciation linger among many speakers after the lexicographer has not only preferred the new but discarded the old accent even as a variant. These primary and final stages in the history of a shift of accent are not within the lexicographer's horizon. But to complete the perspective, we add some examples of these stages in the following classification of specimens.

Summarizing, we find that the general shift of English accent is to or toward the beginning of the word, but that it may be restrained by (1) the tendency to differentiate the verb from other parts of speech, (2) the difficulty of pronouncing too many unaccented syllables, and (3) prefixes.

With this general concept in mind we may arrange the specimens as follows to illustrate the stages through which a shift of accent passes into, through and out of the dictionary. The list of variants recognized by the lexicographer are full; the other specimens are simply illustrative.

(1) In the following words the shift of accent from the second to the first syllable is not yet acknowledged by the dictionary as a variant*: —

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*The following abbreviations are used: n., noun; a., adjective; ad., adverb; v., verb. Other letters in parentheses are variant spellings.

Ad′dress (n.), ad′ept (n.), ad′ult (n.), al′loy (n.), com′bine (n.), es′crow (n.), in′trigue (n.), re′tail (v.), ac′climate, ac′umen, al′bumen, back′gammon, con′summate (ad.), ex′culpate, hor′izon, in′quiry, mu′seum, oc′topus, op′ponent, or′deal, cur′ator, va′gary, prec′edence, i′dea, con′dolence, in′terment.

(2) In the following words the lexicographer admits the accent on either of two syllables, still preferring the older accentuation,

On the second rather than the first syllable : —

Ally, annex (n.), atoll, Balkan, basalt, camphene, canine, cement, comment (v.), contour, costume, cuirass, decrease (n.), defile (n.), depot, detail (n.), diverse, ensign (v.), expert (n.), finance, gourmet, inverse, levee, madame, narrate, oblate, papa, penult, peruke, portent (n.), prestige, saline, shellac, survey (n.), tolu, toucan, undress (a., n.), vignette, vizir, waylay, jaguar, abdomen, acerbate, antiquist, archival, aspirant, Bodleian, caffeic, caffein, caffeone, cephalic, chiragra, compensate, composite, concentrate, confiscate, conflagrate, conglobate, constellate, consummate (v.), contemplate, coruscate, decorous, demonstrate, despumate, discrepant, diversely, enervate, envelop(e) (n.), environs, excretal, excretive, expurgate, exsiccate, extirpate, illustrate, inundate, ogival, perfume (v.), pertubate (v.), phlegmatic, placard (v.), plethonic, prelude (v.), progress (v.), recondite, samara, splenetic, subsidence, synclinal, trachea, trilobate, viola, accessary, accessory, acetamid(e), acetylene, actiniform, adeniform, alveolar, alveolate, antennary, appetitive, camelopard, chalcedony, consistory, decorously, decorousness, discrepancy, disputable, enervate, executive, febrifugal, illustrator, prolocutor, prolocutrix, reconditeness, accessorily, accessoriness, alveolary, alveolated, disputableness, dissylable, inspiratory, prolocutorship, respiratory.

On the third rather than the first syllable : —

Abatis, avatar, badinage, mandarin, adjectival, connectival, genetival, mandarinate, mandariness, mandarinism, relatival, substantival, adjectivally.

On the fourth rather than the first syllable : —

Nominatival.

On the third rather than the second syllable : —

Infecund, renaissance, subsaline, bicephalic, climacteric, empyreal, empyrean, encephalic, indecorous, postcephalic, procephalic, quadrijugate, quadrijugous, reinundate, indecorously, indecorousness, indisputable, indusputably, undisputable, undisputably, indisputableness, undisputableness.

On the fourth rather than the second syllable : —

Comparatival, diminutival, distributival, imperatival, infinitival.

On the fourth rather than the third syllable : —

Achlorophyllous, acrocephalic, and 27 other compounds of cephalic, interaccessory.

On the fifth rather than the fourth syllable : —

Anthropomorphosis, brachiocephalic, and 11 other compounds of cephalic.

On the sixth rather than the fifth syllable : —

Amyelencephalic, platybrachycephalic, prosodiencephalic.

(3) In the following words the lexicographer authorizes the accent on either of two syllables, now preferring the new accentuation,

On the first rather than the second syllable : —

Access, adverse, alcove, appulse, asphalt, basset, baton, berlin, bezant, bouget, brogan, buffet, calcine, chopine, concrete (n.), consols, construe, content (n.), curvet, duress, egress, enema, essay (n.), exile, extant, fecund, firman, frontier, glacis, Hindu, holla, impulse, innate, increase (n.), inlay (n.), inside, Koran, legume, magot, morel, ogive, outside, perfume (n.), permit (n.), placard (n.), prelude (n.), presage (n.), prescript (n.), pretext, prolix, purport, quinine, rampage, sepoy, sojourn, spinel, spinet, tapis, traverse (ad.), upright, acetous, adjuvant, agaric, alternate (v.), Byzantine, calciner, cantonment, cathedra, cissoidal, commenter, concretely, concretism, concreteness, denudate, equer(r)y, exarchate, exedra, fecundate, frontiersman, imbecile, innately, innateness, interstice, jerboa, levantine, momental, Nemean, obdurate, perfecter, perturbate (a.), prolixly, prolixness, quandary, racemous, recusant, reflex, remigrate, renitence, renitent, Sabaoth, sojourner, sojournment, subaltern, trijugous, tripartite, advertise, aeoliphile, aggrandizement, aristocrat, Byzantism, calcinable, capillary, cephalod(e), cuneiform, deflagrable, excretory, exemplary, heresiarch, liberticide, obduracy, orthoepy, polyphony, renitency, telegrapher, telegraphist, telegraphy, telepathist, telepathy, telescopist, telescopy, tripartitely, vindicative, advertising, axinomancy, calcinatory, capillariness, exemplarily, exemplariness, recognizable, recognizably.

On the first rather than the third syllable: —

Alcoran, amateur, artisan, calipash, calipee, Capuchin, caravan, clarinet, cochineal, aristocratism.

On the second rather than the third syllable: —

Chimpanzee, consignor, tramontane, whereinto, advertisement, apophyllite, elegaic, elegiast, gerundival, Himalayan, alveoliform.

On the third rather than the fourth syllable: —

Anamorphosis, apotheosis, apotheosize, Archimedean.

On the fourth rather than the fifth syllable: —

Dolicocephalic, heliogravure.

On the fifth rather than the sixth syllable: —

Subdolicocephalic.

(4) In the following words, the shift of accent to the first syllable has been so far accepted that the former accent on the second syllable is referred to as "formerly," or "properly pronounced," the "properly" referring to the old classic pronunciation: —

Altern, bombast, reflex, triumph (v.), balcony, infamous, sinister, vertigo, hydrangea.

(5) In the following words the lexicographer has accepted the shift of accent to the first syllable and utterly discarded the old accent on the second syllable, although originally correct and still heard among some speakers: —

Blasphemous, conversant, mischievous, orator, contrary.

The shift or accent illustrated by the foregoing specimens is a general tendency subject to occasional interference by tendencies in the development of language.

The uneducated say *defic'it* instead of *def'icit*, in analogy with *defic'ient*. The educated often say *pare'sis* instead of *par'esis*, in analogy with other medical terms ending in *itis*, frequently pronounced as *cetis*. So we have *Au'gust* and *august'*, forms of the same word, where the name of the month has suffered the general shift of accent, while the adjective has resisted it by reason of the tendency of speech to express a differentiation in meaning by some opportune variation of form.

Such apparent exceptions to the tendency we have been illustrating are just sufficient in number to emphasize the fact of the general shift of accent and to show that other tendencies of development oppose, modify and check it under special conditions. The consideration of these cases must be postponed to a future article. The object of this is attained if its collation of specimens shows that the lexicographer, despite his assumed authority to dictate a correct pronunciation, is forced, by admitting these variant accentuations, to acknowledge that in these cases neither is solely correct and, perhaps unwillingly, to testify to that continuing change in the forms of language which means thought, action and progress in its speakers.

* * *

It may be pertinent to the idea of this article to close with citing the noun *automobile* as an example of a word that is earnestly trying to adjust itself to the phonetic and significative laws of English accent. *Mobile*, though an adopted word, has long been established in English — long enough to have produced the offspring *mob*, now, after long resistance by the purists, thoroughly legitimated and adapted to a particular meaning needing a name. Much later appeared the scientific word *automo'bile*, accented on the third syllable because the few speakers who used it were conscious of the significance of its parts, *auto* and *mobile*. Now a locomotive machine appears which is, compared with other carriages, automobile. The word thus becomes used as a noun. But the accent of English nouns strenuously seeks the first syllable, and we now hear *au'tomobile*. Yet the machine is international, and under the influence of the French pronunciation we hear *automobile'* (i = ee). Some still hold to the adjective pronunciation and say *automo'bile*. The word, too, meets with difficulty in English because it has four syllables — two or three too many for an active English noun. Sporadic attempts at clipping have already begun. We hear *auto*, *autoist*, *autoing* — just as *cabriolet* has been cut to *cab* and *omnibus* to *bus*. The chaffeur himself avoids the word and calls it *machine*, *motor* or *car*. The thing is seen in use by all and the community — unknown to its individuals — is experimenting with its name and will finally select a modification or substitution in conformity with the laws of English phonetics. After the selection has been made by the community, the dictionary will take notice and record the new accent, the new abbreviation, the new word, or the new meaning of an old word, as the case may be. It will first admit this new term as "colloquial," or "sometimes heard," or "usually," or even "among chaffeurs," then as a real variant in pronunciation or meaning, and so on through the process of legitimation. "*Locomotive*" has been subjected to similar conditions. The adjective is *locomo'tive*, but when used as a noun the people say *lo'comotive*. But, better than that, they generally say simply *engine*, in which term its euphony has counterbalanced its lack of specification of meaning and won the day.

MINUTES OF THE INSTITUTE.

AUGUST 5, 1909. — Regular monthly meeting, President T. Chalkley Palmer in the chair. Reports of committees, Curators, etc. The committee on naming and labeling the trees in the Court House Square, Media, a work which is being done under the direction of the Institute, reported progress. The following additions to the library were announced: Report of the Commissioner of Education for 1908; Desert Watering Places in Colorado and Nevada; Water Supply Investigations in Yukon; Disinfection of Sewage and Sewage Filter Effluents; Surface Water Supply of Nebraska; Geology and Water Resources of Oregon; Mineral Resources of Alaska; Briquetting Tests at the United States Fuel Testing Plant, Norfolk; Forty Mile Quadrangle, Yukon; The Fire Resistive Qualities of Building Materials; Contributions to Economic Geology. Two specimens of drinking water, one from the Media reservoir and the other from the stand pipe, both containing a greenish sediment, the nature of which was undetermined, were placed on exhibition. This greenish sediment had developed after the samples had remained corked up several weeks. The matter was submitted to T. Chalkley Palmer for further examination. On behalf of Peter Ober, of Media, an Indian battle axe with two grooves around it, found near Spring City, Chester County, in 1908, was presented to the museum. Alfred S. Barker made some interesting remarks concerning the fresh water *Hydra* and snail eggs. In one instance mentioned the *Hydra* had placed its pad against an egg and the pad was then observed to flatten and cover a considerable portion of the surface. The fact that after a short time the *Hydra* suddenly let go, combined with the fact that the egg retained its shape, seemed to indicate that the creature had sucked the egg. President Palmer reported having observed a rotifer extracting the contents of a *Closterium* in a manner comparable to a man drinking from a bottle, but failed to find any aperture through which the protoplasm had been withdrawn. Sanford Omensetter exhibited a living specimen of the dog tick (*Dermacentor electus*). On motion adjourned.

SEPTEMBER 2, 1909. — Regular monthly meeting, President Palmer in the chair. Routine reports of committees and officers. Additions to the library were announced as follows: Fox Hunting and History of the Rose Tree Fox Hunting Club, and the History of the Eyre and Ashmead Families, both by George E. Darlington, Esq.; eight volumes of the Proceedings of the Sixth International Congress on Tuberculosis. The following Programme Committee for the Winter Course of Meetings was appointed by the chair: — Albert S. Barker, Robinson Tyndale and Henry L. Broomall. Director Albert S. Barker, of Section A, made a very gratifying report of the work of the Section. Edward V. Streeper, Jr., on behalf of Mr. Gustav Edling, of Philadelphia, presented a handsome specimen of Madrepore Coral from Jamaica. President Palmer exhibited a specimen of *Cicada* in a state of coma produced by the sting of the Digger Wasp (*Sphecius speciosus*). After discussion the meeting adjourned.

OCTOBER 7, 1909. — Regular monthly meeting, President T. Chalkley Palmer presiding. Reports of committees, Curators, etc. The Committee on Programme reported arrangements made for the Winter Course of Meetings as follows: — First Thursday of each month, business meeting; second Thursday, lecture; third Thursday, Section A; fourth Thursday, lecture. Robinson Tyndale presented to the museum a Chinese bow and arrows, which had formed part of the military equipment of a company of soldiers recruited from the interior of China during the recent war with Japan. C. M. Broomall spoke of some recent observations of a group of sun spots visible at the present time. After a general discussion on astronomical topics the meeting adjourned.

October 14, 1909.—Adjourned meeting. Lecture on "Eugene Field," by Dr. E. D. Fitch.

October 28, 1909.—Adjourned meeting. Lecture on "Bird Plumage and Coloration," by Prof. Charles W. Palmer, of the Department of Science, Westtown School.

MINUTES OF SECTION A.

August 12, 1909. — Miscellaneous scientific business, presentation of specimens, etc. An old map of Delaware County, original author unknown, dated 1810, recently found among the archives of the Institute, was exhibited. Among other things, T. Chalkley Palmer made a report of a microscropic examination of a sample of Media drinking water, which at this time was exceedingly offensive in taste and odor. The result of the examination may be found in full among the records of the Section, and shows a numerous growth of animal and vegetable organisms. Chemical analysis by C. M. Broomall confirmed the bad character of the water. Subsequently, it may be noted, after a thorough cleaning of the reservoir, the water returned to its original first class quality. A simple apparatus for comparing the intensity of two lights, consisting of a cube of white paraffine divided by an opaque septum, was exhibited. Albert S. Barker exhibited a microscopic collection of hairs from the mouse, elk, rabbit, bat, camel, monkey, etc.

August 19, 1909. — Miscellaneous scientific discussion and presentation of specimens. Albert S. Barker exhibited a varied collection of interesting microscopic objects, including brown aphides, *Vaucheria*, *Spirogyra* in conjugation, *Chelifer cancroides*, etc.

August 26, 1909. — General discussion and exhibition of specimens. C. E. Ogden and Sanford Omensetter spoke at length on the habits of the chimney swallow in this locality. Dr. B. M. Underhill presented specimens of crinoids and fossil ferns and spoke of their position in geological history. The following specimens were presented and discussed: — Digger wasp, diatoms, insect eyes, etc. Albert S. Barker showed a live plant louse found on a beech tree, where large black ants were caressing it in an effort to obtain honey dew.

SEPTEMBER 9, 1909. — General discussion and presentation of botanical and other specimens. Sanford Omensetter presented a specimen of *Speiranthes gracilis*, found near the Black Horse, Middletown township, this county. The principal topic of the evening was astronomy, the discussion covering comets, planetary motion, measurement of time, etc.

SEPTEMBER 16, 1909—Albert S. Barker exhibited through the microscope the individual images formed by the facets of the compound eye of the Sphex insect, and illustrated the optical principles involved by blackboard diagrams. He also exhibited specimens of marine diatoms ; also the fibres from the rear of the eye of the Sphex insect. C. M. Broomall exhibited a fungus which had been treated with Millon's reagent, showing the preservative and hardening action thereof and the increased red color in the parts of the fungus where the natural odor was the most pronounced. He also mentioned the presence of a small beetle inhabiting the fungus. Miscellaneous discussion.

SEPTEMBER 23, 1909. — Miscellaneous scientific meeting. Among other things Charles Potts spoke of a method of progression which he had observed in the common grub worm when laid upon a plane surface, the creature throwing itself on its back with its feet in the air and moving along by a kind of wriggling motion. Sanford Omensetter exhibited a cicada and described the mechanism concerned in operating the sound drum. Albert S. Barker gave an account of the life history of the "white rust," as found on lilac bushes. General discussion.

SEPTEMBER 30, 1909. — C. M. Broomall reported some observations of a group of sun spots at this time visible. Also with diagrams and the gyroscope illustrated the interrelation of the axis of figure, resultant axis and the instantaneous axis, as concerned in the phenomenon of "variation of latitude" on the earth. Albert S. Barker exhibited various interesting microscopic specimens, including the sting of the Sphex insect.

OCTOBER 21, 1909.—T. Chalkley Palmer, speaking of diatoms, mentioned *Bacillaria paradoxa*, a species first described in 1780, describing its peculiar method of motion. C. E. Ogden exhibited a large collection of *Volvox* collected near Strathaven Inn, Swarthmore. John W. Palmer exhibited specimens of the same organism collected about 15 years ago, which were still in good condition. Albert S. Barker exhibited a specimen of *Nitella*, of the Order *Caracæa*, commonly known as the stonewort, especially noted for the strong movement of protoplasm in its internodes.

INSTITUTE NOTES.

The Summer's work of Section A for 1909 has been completed. A glance over the minutes will give some idea of the different lines of investigation pursued. The meetings have been held three times a month, have been well attended, and the members have derived much benefit from them. The officers of the Section deserve much credit for their work.

During the early part of the past Summer the residents of Media were for a time much annoyed by the extremely offensive taste and odor of its water supply. So bad did this become that it was necessary to clean the reservoir, a proceeding which remedied the trouble. The reservoir was found to contain a large amount of decaying animal and vegetable matter. A test of a sample of water from the reservoir, on July 25th, 1909, gave the following results : —

Albuminoid Ammonia......	.305	parts per million
Free Ammonia.............	.105	" " "
Total Oxygen..............	2.5	" " "
Nitrites.....................	high	

In connection with the above, the following comparison of nitrite content in reservoir, stand pipe, dam and Ridley Creek is interesting. The results are given in an arbitrary scale, for comparison only : —

Dam, 5 Reservoir, 4 Creek, 2 Stand pipe, trace

These tests were also made on July 25th, 1909.

The meagre rainfall of the Summer of 1909 has been most remarkable. Many springheads in this locality went dry and vegetation suffered very much. The balance of nature, however, will probably make this up to us another Summer. Although there is no doubt of the evil effects of deforestization, it is not probable that a sudden decrease of rainfall and of underground water supply could result from this cause.

The Curators of the Institute have been considering the advisability of installing a hot water system of heating in the Hall. The present system is not entirely satisfactory and if some such improvement could be made it would be acceptable.

Albert S. Barker reports the finding of *Spirogyra* in conjugation on August 19th, 1909. This is an unusual time of year for this process to occur, at least in this locality. In the present case three filaments were concerned in the process, the spore formation occurring, however, in only the two outside filaments.

C. M. Broomall reports a weir measurement of the flow of Ridley Creek, above the Media water works dam, on September 1st, 1909, of 3,950,000 gallons per day. Considering the very small rainfall of this year this may be considered as about the minimum flow of Ridley Creek.

The work of labeling the trees in the Court House Square, Media, with proper common and scientific names, has been completed. At the instance of Judge William B. Broomall, the County Commissioners were induced to supply the necessary signs, in the shape of neat, little metal plates, appropriately marked. The naming was done by the botanists of the Institute, after consultation with horticultural specialists.

ERRATA:

Page 15, line 1 — For "guage" read "gauge."
Page 37, line 3 — For "indusputably" read "indisputably."
Page 38, line 27 — For "shift or accent" read "shift of accent."
Page 40, lines 8 and 18 — For "chaffeur" read "chauffeur."

Officers of the Institute:

President,	T. Chalkley Palmer
First Vice President,	Henry L. Broomall
Second Vice President,	Charles Potts
Secretary,	Dr. B. M. Underhill
Treasurer,	Carolus M. Broomall
Librarian,	Henrietta K. Broomall

Board of Curators,

Edgar T. Miller, Homer E. Hoopes and the Officers

Vol. V, No. 2 January, 1910

PROCEEDINGS

OF THE

DELAWARE COUNTY
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THEORIES AND FACTS OF ARTHROPODAL VISION.

BY ALBERT S. BARKER.

ILLUSTRATIONS FROM PREPARATIONS AND PHOTOMICROGRAPHS BY THE AUTHOR.

"Quelque rationelle que semble une theorie celle-ci n'a jamais qu'une faible valeur tant qu'elle n'a pas été confirmée par des expériences multiples et variées."—F. Plateau.

"When I removed the tunica cornea a little from the focus of the microscope and placed a lighted candle at a short distance, so that the light of it must pass through the tunica cornea, I then saw through it the flame of the candle inverted, and not a single one, but some hundreds of flames appeared to me, and these so distinctly (though wonderfully minute) that I could discern the motion of trembling in each of them."—Antonius von Leeuwenhoek.

The observation recorded in the lines above was made two hundred years ago with what would now be termed a simple microscope, the only type of microscope known at that early period; but it may be noted that as compound microscopes had not then been invented and as the desire for higher powers was as urgent as it is in our day, the capacity of the simple microscope was pushed far beyond what we try to attain now, and Leeuwenhoek had one giving a magnification of 270 diameters, with which instrument, still in existence, Harting was able to resolve the fourth group of Nobert's test-plate.

It is probable that Leeuwenhoek's microscope was the earliest form in which it was possible to adjust the focus, this being effected by a screw movement to draw the object toward the lens against the counteracting pressure of a spring.

With such an instrument this great Dutchman discovered the red blood corpuscles and other minute forms with which every histologist is now familiar; but as a matter of fact it will be shown that his high powers were not needed for the demonstration of the formation of images by the corneules of the arthropodal compound eye, though the focussing arrangement was indispensable.

It is well known, of course, that the tunica cornea of the compound eye, or what we now simply term the cornea, is a hard, firm tissue, composed, with few exceptions as to number,* of thousands of distinct units termed corneules, or, superficially considered, facets, which are usually, but not invariably, hexagonal in outline and more or less convex both posteriorly and anteriorly (Plate I, Fig. 1; Plate II, Figs. 7 and 9), but while many persons are familiar with the statement that each of these corneules will form a distinct image of external objects, the writer believes that few have ever seen them, though satisfactory arrangements can be made with little difficulty by any possessor of a microscope.

Remove the eye of an insect whose eyes have large facets, the dragon-fly for instance, and dissect away all except the cornea, carefully cleaning the interior with a camel's hair pencil. Take a small portion of this tissue and mount it "dry" or in a medium of low refraction, the anterior or outer face of the cornea being placed downward. On a circle of tracing paper about three-quarters of an inch in diameter draw a star, rosette, or other simple design one-fifth of an inch or less in diameter, making it as black as possible for the sake of contrast. Fasten this to a carrier of some sort, having an aperture a trifle smaller than the diameter of the tracing paper, and support it beneath the stage. It will be advantageous to arrange it to permit rotation, but that is not indispensable. Now illuminate the design with the strongest beam of light obtainable, and focus upon the mounted fragment of cornea (this having been placed upon the stage, of course, in the usual position), using a moderate or low power. The hexagonal facets of the posterior or inner surface of the cornea will now be seen (Plate 1, Fig. 1), and on focussing downward the anterior surface will come into view. But now rack up slowly until the facets disappear, and when a certain plane a small fraction of an inch above the object is in focus, the images of the design beneath the stage will appear, one complete image above each facet in the field of the optical combination in use (Plate 1, Fig. 2).

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* Folsom states that the worker ant of Eciton has at most a single facet on each side of the head.

If the prepared design is such as to show change in orientation it will be observed that the images are not inverted as in Leeuwenhoek's experiment, and this is merely because the compound microscope erects the inverted images formed by the corneules at their foci, which the simple microscope did not do.

Certain measurements made by the writer may be tabulated as follows, the subject being the dragon-fly's eye: —

Distance of design below the stage,	2.37	inches
Diameter of design...............	.187	"
Diameter of a corneule...........	.003	"
Focus of a corneule...............	.012	"
Diameter of image.................	.0015	"

These figures will indicate the order of the dimensions with which we have to deal, though there is much variation even in the same eye.

But these experiments or demonstrations do not throw much light upon the nature of arthropodal vision. Many of the creatures of this group have only simple eyes, called ocelli, and resembling, superficially, the eyes of vertebrates. Some have both simple and compound eyes, some compound eyes only, and some no eyes whatever — yet they see.

As stated above, the simple eye of the arthropod superficially resembles the vertebrate eye, but the anatomical details are quite different. In the vertebrate eye the optic nerve penetrates the retina and spreads out on the inside, forming the fibrous layer which covers the rods and cones, whose free ends are directed outward, and the space between the fibrous layer and the lens is occupied by the vitreous humor; but in the simple eye of the arthropod the bacillary layer is lacking or is represented by the visual rods or ommatidia (retinophores of Patten), occupying the greater part of the space between the nerve layer and the lenses. Owing to the great convexity of these simple eyes, their foci are short and the images formed by them are small.

The simple eye is the only kind possessed by *Myriapods* (with a notable exception), *Arachnids*, the larvæ of most insects, and some of the *Crustacæa*.

The notable exception of the *Myriapoda* is *Cermatia*, which has compound eyes only.

One of the most interesting of the simple eye class is a terrestrial crustacean which nearly everybody has seen, some knowing it as the wood louse and others as the hog louse. Its name in science, however, is *Oniscus*. This creature has two groups of simple eyes, with about twenty ocelli in each group (Plate II, Fig. 6), a number which is exceeded in few arthropods.

Some species of *Oniscus* live under the bark on rotting windfalls, and others beneath stones in the open fields, always shrinking from the light and running for cover when exposed.

Many insects have ocelli in addition to the compound eyes, usually three in number, arranged in a triangle. They are, however, unknown in butterflies with one exception, and are possessed by few beetles. Amongst the moths, however, there are many having two.

Several authors, including Folsom, agree in the statement that the arthropod with simple eyes must be very near sighted owing to the great convexity of the lens and the absence of accommodation. But this implies that the receptive elements are too far back to be in the focus of parallel rays, which has not been proven.

It is true that the images of distant objects must be extremely minute, the foci being shorter, in some cases at least, than the foci of the corneules of compound eyes, and the focal plane is correspondingly close to the lens, but it may be shown, perhaps, that the receptive elements extend to that plane. It has been stated, moreover, that the lens is made up of layers of different curvatures and different indices of refraction, from which F. Dujardin inferred that there would be as many successive images behind the lens as there were zones with these differences. Adding experiment to theory, he exhibited at the Academy of Science, Paris, in 1847, a telescope whose objective was composed of several zones, and which, the ocular remaining fixed, gave four distinct images for as many distances in the field of view. He claimed also that he had obtained similar results with actual ocelli.

The compound eye was at one time supposed to be an assemblage of simple eyes, but that view is not now entertained. It is a highly complex organ, of which the facetted cornea is only a superficial layer. The structure and functions of the related parts have been carefully studied by many able investigators, one of whom, Professor Sigmund Exner, of Vienna, concludes that the zoologist who has mastered the compound eye will find the vertebrate eye an easy task.

At an early date it was found that behind each of the corneules, as the facetted divisions of the cornea are termed, there is a transparent body, now called pyramid, crystalline cone or crystalline lens (Plate 1, Fig. 3), and that these pyramids or cones were separated from each other by opaque pigment. This arrangement suggested the mosaic theory of Johann Müller, who supposed that the rays of light collected by any corneule would be converged to a point on a retinal surface at the inner end or apex of the cone, and he describes the theoretical result as follows: —

"An image formed by several thousand separate points, of which each corresponds to a distinct field of vision in the external world, will resemble a piece of mosaic work, and a better idea cannot be conceived of the image of external objects which will be depicted on the retina of beings endowed with such organs of vision than by comparing it with perfect work of that kind."

It appears that Müller supposed the cones to be empty tubes radially arranged, each with a minute aperture, resting upon a retinal surface. If that were true and if the foci of the corneules were always the same as the length of the cones, then a strong probability would be established; but neither of these things is true.

However, his view was not seriously attacked until the year 1852, when Gottsche disputed the mosaic theory on the ground that each separate corneule gives a separate and distinct image; and although this fact was not new, Leeuwenhoek and others having observed it, his statement made a great impression upon all who were interested in the subject. In the words of Dors, the theory of Müller was "abandonné par tout le monde."

Gottsche was not merely a curious observer of the images formed by the corneules. He had studied the whole structure of the compound eye, and notwithstanding the presence of the cones, which he knew as solid refracting bodies, he believed that images were formed on a retinal surface.*

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* As the statements found in the best text books of a science may be supposed to fairly represent the state of that science at the period of publication, we quote the following from Orton, 1876: "But the proper visual organs of Lobsters, Crabs and Insects are two compound eyes, perched on pedestals, or fixed on the sides of the head. They consist of an immense number of ocelli pressed together so that they take on angular forms — four-sided in Crustacea, six-sided in Insects. They form two rounded protrubances, variously colored — white, yellow, red, green, purple, brown, or black. Under the microscope the surface is seen to be divided into a host of facets, each being an ocellus complete in itself. Each cornea is convex on one side, and either convex or flat on the other, so that it produces a focus like a lens. Behind the cornea or lens is the pigment having a minute aperture or 'pupil.' Next (in place of

In 1880 Huxley published his memorable monograph on the crayfish, in which the structure of the compound eye of this animal is treated with characteristic thoroughness. He reached the conclusion that the explanation of vision with compound eyes would be found in a modification of Müller's theory, the modification suggested being this: Since the pyramids through which the rays collected by the corneules must pass are not empty tubes, but are solid, refracting "rods," we may suppose that a part or the whole of this visual rod "is not merely a passive transmitter of light to the nerve fibre, but is itself in some way concerned in transmuting the mode of motion, light, into that other mode of motion which we call nervous energy. The visual rod is in fact to be regarded as the physiological end of the nerve, and the instrument by which the conversion of one form of motion into the other takes place."

Lubbock supposed that the crystalline cone in most cases destroyed the corneal images, and he stated positively that such is the case in *Lampyris splendidula*, to which subject we shall have occasion to refer later in connection with an examination of Exner's researches. Lubbock also warns us that "we must not attach too much importance to the mere presence of an image. Any lenslike object, even a globule of fat, will give one. Moreover, as Müller and Helmholtz have shown, the lens of the cornea would be an advantage in the theory of mosaic vision by assisting to condense the rays of light in the termination of the nerve."

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the vitreous humor of vertebrates) is a conical tube — one for each facet with sides and bottom lined with pigment. These tubes converge to the optic ganglion, the fibres of which pass through the tubes to the cornea. Vision by such a compound eye is not a mosaic; but each ocellus gives a complete image, although a different perspective from its neighbor. The multiplied images are reduced to one mental stereoscopic picture on the principle of single vision in ourselves." — Comparative Zoology, Structural and Systematic, by James Orton, A. M., Professor of Natural History in Vassar College. New York, 1876.

In this connection it may be stated that images may be obtained through detached crystalline cones of some insects in any direction with more or less distortion (Plate 1, Fig. 5), and an image practically free from distortion is obtained when two of these cones are crossed at right angles, and the image forming rays pass through both in a direction perpendicular to the axes.

Grenacher repeated the experiments of Gottsche, using moths' eyes in which the crystalline cones are firmly attached to the cornea (Plate 1, Fig. 4), so that it was possible to remove the soft parts without disturbing the cones. Under these circumstances he found that images were formed *within* the cones. Exner obtained these images by cutting off the inner ends of the cones and focussing on the surfaces thus exposed, and the writer has a slide in which they may be seen in optical section without amputation.* Exner had previously experimented with the eyes of *Hydrophilus*, the great black water beetle, but the pyramids always came away from the cornea. He calculated the corneal refractions, however, and concluded that an image on the retina was impossible.

In 1885 Felix Plateau began a series of experiments with arthropods and other animals, the results of which were communicated to the Royal Academy of Belgium in 1887 and 1888. The keynote of Plateau's work is found in the quotation at the head of this article, which may be translated as follows: "However rational a theory may seem, it has but little value so far as it has not been confirmed by repeated and varied experiments." He finds that nearly all of his predecessors and contemporaries have fallen into error by confining themselves to anatomical investigation, neglecting the important testimony of behavior under control conditions, and though we may not accept all of his conclusions we must admire his skill and patience in handling a difficult question, and admit that his evidences are at least as worthy of consideration as those of the anatomists, especially since there is amongst the latter a wide divergence of opinion concerning the optical and sensorial functions of the organs in question. Plateau found that the anatomists having decided that the crystalline cone was a second refracting body in the optical system, were divided in support of two theories. "Gottsche, Leuckart, Claparède, Lemoine, Max Schultze, Harting and Thompson-Lowne, though differing in matters of detail, assert that the crystalline cone causes a new refraction of the rays which have traversed the cornea, finally producing an image on a retinal surface, or in a retinal region at a greater or less depth in the group of cells below the cone; while P. Lyonet, J. Müller, Zenker, Grenacher, Exner and Carrière, either see in the crystalline cone an organ whose function is to concentrate the greater part of the light rays which fall upon the cornea into a beam directed along the axis of an ocular element, or endeavor to prove that the presence of the cone renders the production of an image impossible." (Plate 2, Fig. 8.)

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*In this case the field of view of each of the units embraced an angle of about 20°.

Plateau subjected both arthropods and vertebrates to comparative physiological tests very fully described in the Bulletins of the Royal Academy, and reached the general conclusion that the vision of the arthropod is never distinct, even though distinct images may be formed, and that in many cases there is little more than dermatoptic sensation, which in some of them is probably intense, notably, it is said, in the ordinary cockroach. The writer has, however, repeatedly held a lighted match within an inch of the roach's head, and in front of it as well as over it, without causing any apparent alarm or motion, but on a closer approach, when the flame probably touched the animal, it fled precipitately, This experiment was tried in an otherwise unilluminated spot.

Plateau tested many wingless insects in a piece of apparatus which he calls a labyrinth, constructed as follows:— On the top of an ordinary table many small rectangular pieces of card board were set on edge in such fashion that there was no straight open path from one side of the table to its opposite, or to any point which offered escape, but a tortuous path could be found by an intelligent animal endowed with distinct vision. Some of these cards were white, some gray, and others dark brown or black ; otherwise they were uniform. Under these circumstances the insects placed upon the table seemed to be unable to distinguish between solid bodies and open spaces until they either ran against the former or examined them with their antennæ, while vertebrates under similar circumstances avoided the obstacles without difficulty, as was anticipated. Of course, the failures on the part of the insects may have been due to ignorance or bad judgment. A confession of bad judgment on the part of the investigator recorded against himself by Plateau deserves mention. Winged insects of many species were placed in a special dark chamber provided with two windows, one of which was cross-barred or trellised, and the other unobstructed, but of dimensions ensuring equal illumination. The details cannot be given here, but the observations recorded by Plateau seemed to justify his claim that insects did not distinguish form, since they more frequently attempted to pass through the trellis than through the other window. Forel, however, was not convinced. He claimed that the mistakes made by Plateau's insects were errors of judgment which would occur with vertebrates under similar circumstances. Thus challenged, Plateau tried the vertebrates and frankly acknowledges that Forel was right, but nevertheless believes that his experiments with the labyrinth and other experiments in the open air were conclusive.

On the anatomical side he had great faith in the work of an American, W. Patten, whose most important discovery is that a delicate plexus of nerve fibres occupies the upper part of the crystalline cone, an expansion of a nerve bundle traversing axially the entire length of the ommatidium,* except

* A complete radial element or segment of the compound eye of an arthropod. Plate I, Fig. 3.

the corneule. And in support of Patten, J. S. Kingsley is quoted as follows: "I have, however, been able to trace the axial nerve through the pedicel and style and into the distal portion of the crystalline cone." Now no matter where images may be formed, if optic nerve elements are encountered by the light rays at all depths, Plateau asserts that the images will be as indistinct as images in the human eye formed by cones of light rays with foci behind the retina. According to this investigator, then, arthropods without eyes distinguish between light and darkness through dermatoptic perception, and as this form of perception is apparently suited to their needs, we have said of these animals that they "have no eyes whatever — yet they see."

Arthropods having only simple eyes generally have very poor sight, and make much use of the organs of touch to determine the forms and characters of objects, and when the arthropod has both simple and compound eyes, the simple eye is almost useless. Finally, the arthropod with compound eyes does not see forms distinctly but in moving about among motionless bodies it utilizes tactile and olfactory impressions in conjunction with those produced by light.

Plateau believes, however, with other investigators, that many of the insects have a much clearer perception of objects in motion. "At varying distances," he says, "these animals perceive the *displacement* of objects of a certain bulk infinitely better than the objects themselves."

Prof. Exner had studied this subject from time to time during many years before his work entitled "Die Physiologie der Facettirten Augen von Krebsen und Insecten" appeared in 1891. We have quoted him as believing, at an earlier period, that no images could be produced by the optical system of the *Lampyris*, but in this work he presents a photograph of exterior objects made with the *Lampyris* eye, accompanying a learned and lengthy exposition of the principles involved in the production of the image and the precise action of the optical apparatus of this particular animal. In *Lam-*

pyris the crystalline cones in outline resemble short test tubes, and the space between the convex inner ends and the supposed retinal surface is filled by transparent substance which does not materially interfere with the progress of the light rays which form the image.

We accept Exner's photograph as a fact, of course, but may well question some of his inferences. Forced to admit the great difficulty of getting such an image in the numerous eyes whose cones are encumbered with long rods (Plate 2, Fig. 8), threadlike prolongations, spindles, etc., he supposes in such cases another kind of image which he calls an "apposition" image. It is formed, he says, in those eyes whose retinal elements lie close to the crystalline cones. "The upright retinal image of the eye of *Limulus* is formed as a consequence of the beams of light pertaining to the individual members of the compound eye falling upon the retinal plane adjacent to one another." This is obviously the mosaic image under another name. The image obtained with the eye of *Lampyris*, which he calls a "superposition" image, was formed upon a retinal surface, in this case far from the ends of the cones, and he believes that every point of the image received light from at least thirty of the optical units or individual members. He observes also that probably some eyes may yield both apposition images and superposition images.

Dr. Dallinger seems to have misunderstood Prof. Exner, from whom he had a private communication with a copy of the *Lampyris* photograph, for we find in the latest edition of Carpenter's "The Microscope and its Revelations," 1901, page 983, the following statement : —

> "After traversing the pyramids the rays reach the extremities of the fibers of the optic nerve, which are surrounded like the pyramid by pigmentary substance. Thus the rays which have passed through the several 'corneules' are prevented from mixing with each other, and no rays save those which pass in the axes of the pyramids can reach the fibers of the optic nerve. Hence it is evident that as no two ocelli on

> the same side have exactly the same axis no two can receive their rays from the same point of an object, and thus, as each compound eye is immovably fixed upon the head, the combined action of the entire aggregate will probably afford but a single image, resembling that which we obtain by means of our single eyes. This judgment has received a confirmation as unexpected as it is complete and beautiful," etc., etc.

Then follows a description of Exner's experiment, with a reproduction of the photograph and some diagrams.

It seems incredible that Dr. Dallinger could have made such a statement after reading Professor Exner's book, which is filled with discussions of the extraordinary refractions of the cones or pyramids, with the express purpose of showing that other than axial rays can and do pass through the cones and enter into the resultant images.

Dallinger's image seems to agree better with Exner's apposition image or Müller's mosaic.

The image on the vertebrate retina may also be regarded as a kind of mosaic. Here every point of the image is formed by a cone of rays received upon the cornea from a corresponding point of the object viewed, and the assemblage of points of different degrees of illumination and different colors makes the picture.

It may seem that the arthropod with compound eyes has advantages not possessed by the vertebrate. The division of its eye into many units ensures practically parallel bundles of rays from near objects, and hence no accommodation is needed. If any of the images are distinct, they are all distinct, or, if a part of the image is distinct, the whole is distinct, without regard to direction ; while man, at least, must constantly change the direction of his eyes in order that the rays from the most important object in his field of view shall fall upon the fovea centralis, the only spot in the whole eye where a distinct impression can be made ; but there is much evidence that the arthropod is either half blind as to form and character or hopelessly stupid.

In connection with the question of response to light stimulation we must not forget the discovery claimed by Exner, and regarded by him as of great importance, that the pigment masses in different regions of the compound eye are not stationary, but shift their positions considerably under variations in the intensity of illumination, or at least when the change is from darkness to light or vice versa.

He states that his preparations show muscle fibres attached to the iris pigment bundles, by whose contraction the bundles are drawn inward when the eye is exposed to light. At the same time the retinal pigment moves outward, so that the inner ends of the crystalline cones and the zone of the ganglionic cells are both left free from pigment. A *periodic* displacement of the pigment in the eyes of nocturnal lepidoptera which were kept permanently in the dark, has since been reported by A. Kiesel. This phenomenon he believed to be an accompaniment of the insect's sleep.*

Assuming that the reader to whom this paper is addressed has little acquaintance with the subject under consideration, it may also be assumed that he has at this stage recognized the inconclusiveness of what has preceded and will inquire if any definite judgment has been reached by those who can speak with authority.

In the text-book of Parker and Haswell† we find a concise description of the compound eye, as follows: —

> "The surface of the compound eye is marked out as in the case of the crayfish with a great number of hexagonal facets, each of which represents one of the elements (ommatidia). When the eye is examined in section each ommatidium is found to consist of a cornea lens (the outer surface of which forms the facet), a crystalline cone and a rhabdome. The crystalline cone is not always developed, its place being taken in the eyes of some insects by four crystal cells. The rhabdome is an elongated rod. Beneath the rhabdome is a fenestrate membrane, beneath which again is a dense plexus of nerve fibres.

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*SB. K. Akad. Wiss. Wien, ciii (1894).

†A Text-Book of Zoology by T. Jeffery Parker, D. Sc., F. R. S., and William A. Haswell, M. A., D. Sc., F. R. S. London, 1897.

Nerve fibres pass through the fenestrate membrane and terminate in a delicate sheath which encloses each rhabdome, the sheath, together with the nerves that end in it constituting the retinula."

And again on page 514, the function of the sheath cells of the rhabdome is indicated: —

> "Beneath each facet of the cornea is an ommatidium optically separated from its neighbors by black pigment and consisting of an outer segment or vitreous body and an inner segment or retinula formed of sensory cells enclosing a rhabdome."

Still another description of the ommatidia includes the following: —

> "The inner portion is a group of sensory cells constituting a retinula and enclosing a refractive rod, the rhabdome. The retinula is the actual percipient part of the ommatidium, its cells being comparable to our own rods and cones."

Apparently these authors do not attach much importance to the question of the formation of images; at least they have ignored it and if we accept their dictum as to the function of the cells of the sheath enclosing the rhabdome we at once realize the difficulty of assigning a satisfactory place for an image or even a mosaic part of an image, especially where we have the rhabdome itself, "a refractive rod," to deal with. Turning to American text-books we quote briefly from Dr. Weysse* on the arthropod eye: —

> " * * * * In addition there is a pair of compound eyes which consist of a large number of parts, each part a structurally complete single eye."

We might infer from this that even if an image is essential to distinct vision the insect would have a satisfactory picture of sufficiently illuminated objects within a certain range, if furnished with a single ommatidium, and the reader will remember that the worker ant of *Eciton* is said to have at most a single facet on each side of the head.

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*A Synoptic Text-Book of Zoölogy by Arthur Wisswald Weysse, A. M., Ph. D. (Harvard), 1904.

In Folsom's Entomology,* a text-book accepted by universities and colleges of the United States, we find the subject amply treated, the structure of the compound eye being described as follows: —

> "As regards delicacy and intricacy of structure, the compound eye of an insect is scarcely if at all inferior to the eye of a vertebrate. In radial section a compound eye appears as an aggregation of similar elongate elements or ommatidia, each of which ends externally in a facet. The following structures compose or are concerned with each ommatidium: —
>
> 1. Cornea
> 2. Crystalline lens or cone
> 3. Rhabdom and retinula
> 4. Pigment (iris and retinal)
> 5. Fenestrate membrane
> 6. Fibers of the optic nerve
> 7. Tracheæ
>
> "The cone cells may contain a clear fluid, or else as in most insects, are solid transparent cones.
>
> "The rhabdom is a transparent chitinous rod or a group of rods (rhabdomeres) situated in the long axis of the ommatidium and surrounded by greatly elongated cells which constitute the retinula.
>
> "The nerve fibrillæ, which are ultimate branches of the optic nerve, pass into the retinal cells—the end organs of vision.
>
> "Physiology.—After much experimentation and discussion upon the physiology of the compound eye — the subject of the monumental works of Grenacher and Exner—Müller's 'mosaic' theory is still generally accepted, though it was proposed early in the last century. It is thought that an image is formed by thousands of separate points of light, each of which corresponds to a distinct field of vision in the external world. Each ommatidium is adapted to transmit light along its axis only, as oblique rays are lost by absorption in the black pigment which surrounds the crystalline cone and the axial rhabdom. Along the rhabdom then light can reach and affect the terminations of the optic nerve. Each ommatidium does not itself form a picture; it simply preserves the intensity and color of the light from one particular portion of the field of vision, and

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*Entomology, with Special Reference to its Biological and Economic Aspects, by Justus Watson Folsom, Sc. D. (Harvard). 1906.

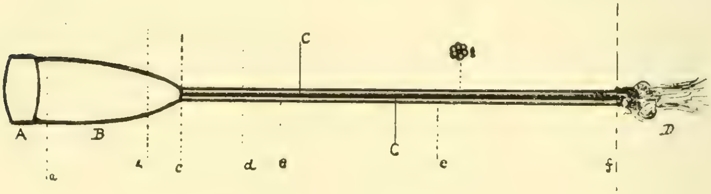
> when this is done by hundreds or thousands of contiguous ommatidia an image results. All that the painter does who copies an object is to put together patches of light in the same relations of quality and position that he finds in the object itself, and this is essentially what the compound eye does, so far as can be inferred from its structure."

Now it appears that Folsom does not accept Patten's statement that there is a plexus of nerve fibres far up in the crystalline cone, but he believes that such fibres do enter the elongated cells surrounding the rhabdom and that these cells are themselves the "end organs of vision," yet he finds that the light rays are transmitted axially along the rhabdoms to form a mosaic image at the terminii. And having stated that each ommatidium is adapted to transmit light along its axis only, he apparently contradicts the statement as follows:—

> "Exner, removing the cones with the corneal cuticula (in Lampyris) looked at them from behind with the aid of a microscope and found that the images made by the separate ommatidia were either very close together or else overlapped one another, and that in the latter case the details corresponded; in other words as many as twenty or thirty ommatidia may cooperate to form an image of the same portion of the field of vision; this superposition image being correspondingly bright—an advantage probably in nocturnal insects."

If, as claimed by Exner, the whole aggregate yields but a single image, it is evident that the view obtained is of the panoramic order, embracing in some cases an angle of more than 180° and including therefore widely separated objects; and of course there is the same comprehensive outlook if a separate picture is formed in each of the cones, and while it may be difficult for the reader to believe that the brain of the dragon-fly has the capacity to arrange and utilize twenty-four thousand optical impressions in any given instant, yet it must be remembered that as the angle of a single element, if we include only the cornea and crystalline cone, is probably not less than 20°, many contiguous ommatidia must give practically the same picture, and further, that the arthropodal nerve system is adapted to the dioptric mechanism, and is far less complicated than that of the human eye, in which there are no less than one million cones in a square one-tenth inch.

The partly diagrammatic sketch of a single ommatidium given below will probably be of use to the reader in locating points touched upon by various authors cited in this paper.



A. Cornea.
B. Crystalline cone (or pyramid).
C. Rhabdom, represented by a black line, but actually colorless and transparent.
D. Ganglia and optic nerve fibre.

a. Region of Patten's plexus of nerve fibres.
b. Plane in cone where images may sometimes be seen.
c. Supposed plane of Müller's mosaic image and Exner's apposition image.
d. Focal plane of corneal lenses.
e. Sensory cells surrounding the rhabdom. These cells are penetrated by optic nerve fibres according to several writers and are termed the "end organs of vision" by Folsom.
f. Retinal plane of some authors. Plane of the superposition image of Exner.
g. Cross-section of the rhabdom with enveloping cells, the rhabdom represented by a black disc to distinguish it from the sheath cells.

Attention should be called to certain anatomical details not previously mentioned.

It is commonly stated that the facets of the eye of the ordinary house-fly (*Musca*) are quadrangular. This is true of some of them, but many of them, possibly the greater part, are hexagonal.

The cornea of the insect eye is lamellar and, under the microscope, fragments will usually show areas near the edges where through exfoliation there are various thicknesses and the foci of the facets of the thinner parts are of course longer than the foci of the corneules which remain intact, and the images obtained through the former are larger.

The eye of the bee is very hairy in parts, as shown in Plate II, Fig. 7.

The pigment is often black, but is in many insects highly colored, yellow, green, brown, purple and red being common. In the house-fly it has the rich color of the garnet, which unfortunately cannot be shown in an ordinary photograph, but the microscopical reader is strongly advised to examine this object in the living animal with low powers and in a fresh dissection with higher powers, for the sake of its beauty.

In conclusion it may be observed that the student who shall undertake further work along these lines must realize that while our own sensory organs present sufficient difficulty to the investigator, notwithstanding that his own consciousness is a constant and valuable aid to interpretation, there is much greater difficulty in the case of the arthropod where there is marked dissimilarity of structure and where we are necessarily shut out from personal experience.

Nevertheless he will be richly repaid for his labor though he may be unable to accept any theory of arthropodal vision already proposed or confidently to offer a new one.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Part of the cornea of the dragon-fly (Libellula) mounted flat to show images. x 55.

Fig. 2. Images formed by the corneules of the compound eye of Libellula.

Fig. 3. Section through part of the eye of Libellula showing crystalline cones and part of the pigment. Much of the pigment was washed away in making the preparation. x 50.

Fig. 4. Cornea and cones of the eye of a moth. The color of the pigment is red. The cones are firmly attached to the corneules. x 125.

Fig. 5. Upper view of detached cones from the eye of a moth. The pigment color appears to be diffused through the cones. x 125.

PLATE II.

Fig. 6. Group of ocelli of the wood louse (Oniscus or Porcellio). x 45.

Fig. 7. Part of cornea of eye of bee showing stiff hairs between the facets. x 250.

Fig. 8. Eye of grasshopper. Section showing cornea, cones, rhabdoms, ganglionic cells and tracheæ. x 35.

Fig. 9. Fragment of cornea of common house-fly (Musca). Some of the facets are quadrangular and some are hexagonal. The red pigment appears nearly black in the photograph. x 60.

Fig. 10. Section through the eye of katydid. The cones are concealed by the pigment which is retained in situ owing to the thickness of the section. x 25.

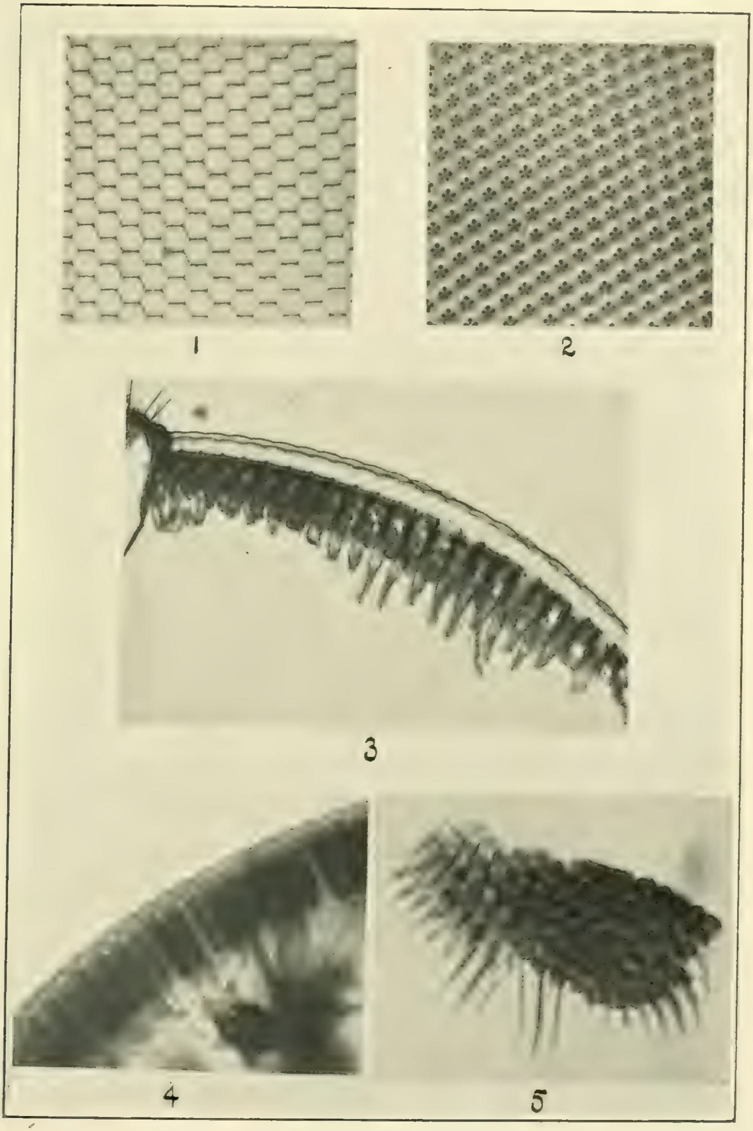
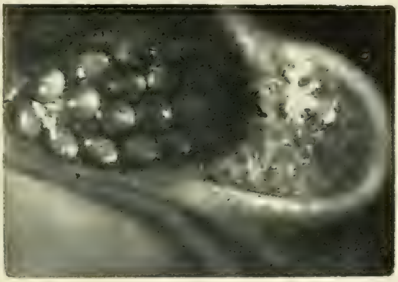


PLATE I.



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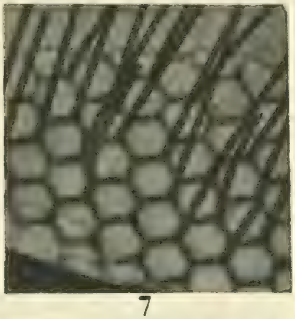

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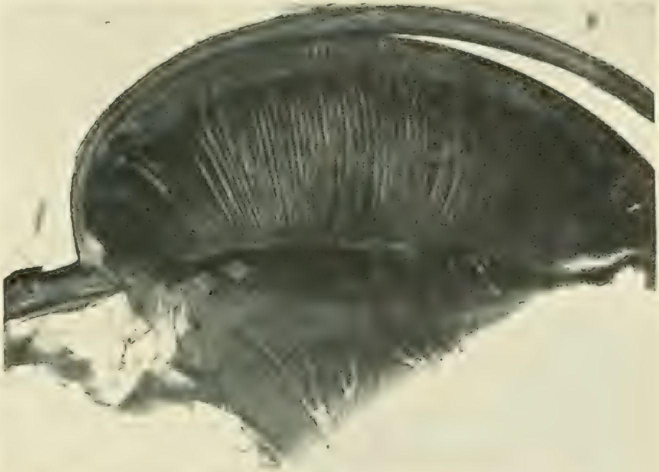

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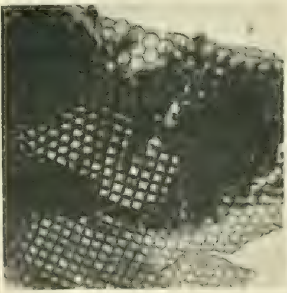

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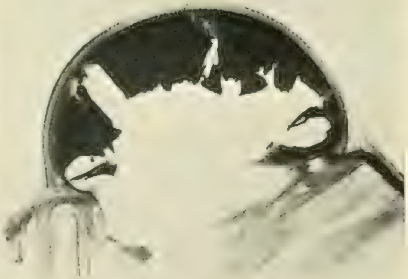

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PLATE II.

A CURRENT VARIATION IN ENGLISH PRONUNCIATION.

BY HENRY L. BROOMALL.

The scholastic ideas which dominate popular education obscure the real nature of language by arranging all its facts around and under the "rule" of the grammarian and the "authority" of the lexicographer. These terms mean absolutism. They inculcate the notion that any form of speech which does not conform to the grammar-book and the dictionary is wrong. They make no allowance for progress in grammar, pronunciation or significance. They would treat our living language as if it were a dead tongue, as if it had no speakers to think, feel and act in advance of their ancestors. Any variation from the "authority" is condemned as deterioration, degeneration or backsliding from the true doctrine.

In previous articles* in this journal it has been shown that many forms of language now legitimated by the grammar-book and dictionary were once mere errors of speech and that many current errors of speech seem now to be developing under the same causes and conditions toward future legitimation. In short, there are errors of speech representing intellectual progress — not deterioration. And further, the authoritative dictionary itself affords evidence of these evolutionary changes when it acknowledges that more than one pronunciation of a word may be correct.

Of the 2234 cases of variant pronunciation sanctioned by the Century Dictionary, 1029 are variations in consonants †, and, of these, 533 are words in which *t* or *d*, followed by *i* or

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* "The Significance of Errors of Speech," Proc. Del. Co. Inst. Sci., Vol. I, p. 30, et seq.

† "Variations of Accent in English Words," Proc. Del. Co. Inst. Sci., Vol. V, p. 29.

y preceding a vowel, vacillates between its original *t* or *d* sound and its palatalized *ch* or *j* sound respectively. For example, the lexicographer sanctions *nature* as *natyur* or *nachur* and *educate* as *edyucate* or *edjucate*. In these specimens, the observer will note that English *ū* is equivalent to *ĭū* or *yoo* and that therefore the *t* or *d* is followed by an *ĭ* or *y* sound, although not graphically represented.

It is the purpose of this article to illustrate the extent of this vacillation of *t* or *d* in support of the foregoing propositions, particularly as we find it acknowledged by the dictionary.

This phonetic process by which *tĭ* or *ty* becomes *ch*, and *dĭ* or *dy* becomes *j*, arises from the mechanical conditions of utterance. Sounds made by different organs of speech, as *p* and *r* in *pray*, where *p* is made by the lips and *r* by the tongue, are easily combined because lips and tongue independently act at the same time without mutual interference. On the contrary, in the case of the combination of *t* with *y* or *ĭ* the tongue is the actor in both sounds and must shift its position quickly. In pronouncing *t* the tongue is nearly to the teeth and the lips relaxed, while in pronouncing *y*, *ĭ* or *ē* the tongue is drawn backward and upward and the lips retracted. Therefore in order to pronounce the word *nature* as *natyure*, the tongue is required in an unaccented syllable to assume rapidly two positions successively the opposite of their predecessors. From *t* to *y* and then from *y* to *u* are thus extreme changes of position of tongue and lips. To decrease the effort required to enunciate these sounds separately, accommodation takes place and the *t* and *y* or *ĭ* are pronounced as one sound with a position of the tongue that fuses both and produces the sound *ch*. While the purist still insists on *natyure* and *literatyure*, he has succumbed to *question* as *queschon* and *soldier* as *soljer* because the additional consonant makes the combination still more awkward and because the words are in more common use. And in time he will say *nachure* and *literachure* because the palatalization, now admitted by the Dictionary, regularly increases in use until the original sound is absolutely supplanted. The change can move in only the one direction.

This process is universal. Its operation in standard English is peculiarly noticeable because we have diphthongized vowels. English long *u* is not equivalent to the Continental European long *u* because we have prefixed to the pure *u* sound the short *ĭ*, whence *ū* becomes *ĭū*, a combination which is practically *yoo*. The diphthongizing of pure *u* into *ĭū* or *yoo* produces the conditions under which palatalization of a preceding *t* takes place. Thus, in pronouncing *nature* as *natyure* the purist is not maintaining the pure *u* sound originally proper to the word, as in *natura*, phonetically *natoora*, but is guilty of diphthongizing the *u* into *ĭū*, which is one step in English progressive phoneticism, and yet refusing to take the next step, which is palatalization of the *t* into *ch*. If his purism is based on history or etymology, his pronunciation should be *natoor*. In short, the purist simply halts at some particular stage of the development and rests there until the inevitable progress of language makes his conservatism absurd.

That this process has been active in the past and productive of improvement rather than deterioration of language may be illustrated by such a word as *journal*. Adopted by us from the French and traced back to Latin we find its origin in *diurnalis*. Here the development of *diu-* into *jou-* took place on the Continent. Its Italian form is *giornale*, in which tongue *gi* is equivalent to English *j*. Having the word *journal*, then, with its particular application in meaning, English uses also the form *diurnal*, adopted directly from Latin, for the special meaning we assign it. This process, therefore, produces two words where there was but one before, which seems like enrichment rather than deterioration of language.

Like processes are and have been operative in all languages, the development extending and assibilating far beyond the specific changes of sound above illustrated. Thus, Latin *nation* has become Spanish *nación*, French *nation*, Italian *nazione* and English *nation*,[*] in which the *i* has converted the *t* into sounds represented by *th*, *s*, *dz* and *sh* respectively. So, too, the intrusive *i* or *e* before a vowel changes a preceding guttural as well as a dental. Thus, Latin *caritas* is now English *charity* and French *charité* (*ch* = English *sh*), old English *cild* and *cirice* (*c* = *k*) are now *child* and *church*; and Latin *factum*, *directum* and *lacte* are now Spanish *hecho*, *derecho* and *leche*. But the present purpose is to illustrate only the first stage of palatalization by which *t* and *d* become *ch* and *j* respectively.

This palatalization of *t* or *d* before *ĭ* or *ĕ* followed by another vowel and equivalent to *y* is a characteristic of English pronunciation recognized by its present speakers to such a degree that they understand *don'tchou* for *don't you* and *didjou* for *did you*. The English ear — at this time — seems to be trained to accept the *t* or *d*, either palatalized or not, without any misunderstanding of the words of which the sounds are components. Hence, *immediately* as *immejately*, *duke* as *juke*, *Indian* as *Injun* and *Tuesday as Chuesday*, *amateur* as *amacheur*, *courteous* as *courchous*, *mature* as *machure*, *opportune* as *opporchune*, are intelligible. These palatalizations are not sanctioned by the dictionary. We now turn to those that are.

The Dictionary sanctions the pronunciation of *t* as *t* or *ch* in the following words: —

Capitulate (5) †, capture, caricature (2), congratulate (5), conjecture, conjuncture, debenture, declinature, digestion, effectuate (2), effectual (2), estuary (2), eventual (5), feature (3), fixture, flatulent (5), fluctuate (3), fortune (3), future (5), fructual (3), gesture (3), gratulate (4), habitual (5), importune (6), indenture, ineffectual (4), infatuate (3), intellectual (9), jointure (2), judicature, lincture, literature, lecture (5), legislature, ligature, mantua, manufacture (4), menticultural, miniature, misadventure (2), misconjecture, misfortune, mixture, moisture, mortuary, multure (2), musculature, mutual (6), nature (8), nervature, nomenclature (2), nurture (2), obituary (4), overture, pasture (4), patulous, peradventure, perpetual (8), petulant (3), photosculpture, picture (5), pinnatulate, piscicapture, pisciculture (2), plantula (2), portraiture, Portugal, Portuguese, posthumous (2), postulate (4), posture, prelature, presumptuous (3), preternatural (5), pretexture, primogeniture (2), projecture, prompture, promptuary, punctual, purpresture, pustule (9), puture, quadrature, rambustious, rapture (4), recapitulate (5), recapture, recaptual (2), righteous (3), ritual (5), robustious (3), rumfustian (2), rupture, sanctuary (2), saturable (5), scripture (8), sculpture (5), sepulture (2), sepurture, serrature, signature, situate (2), spiritual (16), statue (11), striature, stricture, structure (7), sumptuous (5), supernatural (8), supersaturate (2), superspiritual (2), superstructure (2), suture (4), tablature, tactual (2), tarantula (3), temperature, tempestuous (3), tenosuture, tenture, texture (11), tincture (2), tortuous (6), torture (6), triplicature, triturate (5), truncature, tumultuous (7), unctuous (4), uneffectual, unfeatured, unfortunate (3), unigeniture, unlectured, unmanufactured, unnatural (8), unnurtured, unportuous, unpresumptuous, unpunctual (3), unraptured, unsaturated, unrighteous (3), unscriptural (2), unsculptured, unspiritual (3), unstatuable (2), unvirtuous (2), unvoluptuous, ustulation (2), usufructuary, usurpature, vaulture, venture (8), verbiculture, vestiture, vesture (3), viniculture (2), virtue (6), virtuous (3), viticulture (4), vitrifacture, vivisepulture, voluptuary (4), vulture (5), wafture — making 461 words.

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[*] In fact these derivatives of Latin natio are based on the stem nation as it appears in the oblique cases nationem, nationis, etc., but the nominative is cited because the lexicographer has familiarized us with this form.

† The numeral in parenthesis represents the number of words, based on the cited word, in which the same phonetic peculiarity occurs. Thus nature (8) includes natural, naturally, naturalize, etc.

The Dictionary sanctions the pronunciation of *d* as *d* or *j* in the following words: —

Arduous (3), education (5), glandular, gradual (3), grandeur, indeciduous (3), individual (13), modulate (6), nodule (9), occiduous, ordure (2), procedure, prociduous, quadriglandular, residue (8), sedulous (3), supersedure, tedious (3), uneducate (3), unimodular, unindividualized, verdure (2) — making 72 words.

The vacillation of the sound of *t* and *d* under the conditions we have considered warrant the Dictionary in making the following observations quoted from the preface: —

"On the side of consonant utterance, there is a very large class of cases where it can be made a question whether a pure *t* or *d* or *s* or *z* is pronounced with an *i*- or *y*- sound after it before another vowel, or whether the consonant is fused together with the *i* or *y* into the sounds *ch*, *j*, *sh* or *zh* respectively — for example, whether we say *natūre* or *nachur*, *gradūal* or *grajöal*, *sūre* or *shör*, *vizūal* or *vizhöal*. There are many such words in which accepted usage has fully ranged itself in the side of the fused pronunciation; for example, *vizhon*, not *vizion*, for *vision*; *azhur*, not *azūre*, for *azure*; but with regard to the great majority usage is less decided, or else one pronunciation is given in ordinary easy utterance and the other when speaking with deliberation or labored plainness, or else the fused pronunciation is used without the fact being acknowledged. For such cases is introduced here a special mark under the consonant * * * * * which is intended to signify that in elaborate or strained utterance the consonant has its own proper value, but in ordinary styles of speaking combines with the following *i*-element into the fused sound. The mark is not used unless the fused sound is admissible in good common speech."

This is simply recording the vacillation, and perhaps the duty of the dictionary is fulfilled by statement of the fact.

Scientifically, however, the vacillation is a process from one sound to another under the linguistic conditions above described. In the particular sounds here considered the direction of the change is from *t* to *ch* and from *d* to *j*. When the lexicographer thus sanctions a variant pronunciation, it is evident that the process is well advanced in the words above cited. As far as they are concerned, he abdicates his authoritative attitude and refuses to risk a declaration of correct pronunciation. This is scholastic testimony to the fact that a spoken language belongs to its speakers and not to the grammarian and the lexicographer.

A GLANCE AT THE MAMMALIAN DAWN.

BY B. M. UNDERHILL, V. M. D.

The identification of the fossil remains of mammals is beset with difficulties, for, while such fossils as shells and skeletons of vertebrate aquatic animals are often found entire, the relics of animals of terrestrial habit are for the most part fragmentary and may consist of a portion of bone, or displaced groups of bones, teeth or hard products of the skin; very rarely the complete skeleton. The earliest trace that we have of mammals appears in the Upper Triassic, but these are so few and incomplete, consisting of teeth and portions of jaws, that it is difficult to make out their affinities. Practically all that can be said as to the specimens thus far recovered is that they indicate small insectivorous marsupials, ranging from the size of a mouse to that of a rat, to which the opossum is a familiar modern animal somewhat allied.

The hypotheses held as to the relations of these scanty Triassic remains to the Tertiary mammals have been more or less contradictory. Some would remove them from the mammals entirely, claiming that they belong with a group of mammal-like, anomalous, toothed reptiles; others believing them to be representatives of a mammalian type reaching down to the reptiles, to which they are linked by the egg-laying Monotremes. While in the light of our present knowledge any conclusion upon the ultimate beginnings of the mammals must be largely hypothetical, there is a concurrence of present opinion that the unknown reptilian stem from which they evolved split into two branches, one of which, the Monotremes, survives with much of its primitive form in Australia, while from the other branch there arose two divisions, one giving rise to the marsupials, which with the Monotremes constitute the Implacental Mammals, the other developing the Placentalia, which includes all of the remaining orders.

At the beginning of the Tertiary we pass from the mythical to the truly historical; here we suddenly come upon a mammalian fauna exhibiting a state of advancement far beyond the prophecy of any fossil thus far recovered from preceding geological strata; reptiles, which had been dominant in the Mesozoic, are decreasing in size and number and taking a subordinate position to a more modern class, mammalian quadrupeds become the dominant land animals, and the rulers of the sea are great sharks and whales and those of the air birds and bats. Thus the modern faunal aspect commences, or, more properly, this is the first record that we have of it, for the predominance and comparative advancement of the mammals of the Lower Tertiary indicate that there must have been a higher development of the class during the Cretaceous era than has yet been revealed, and that the lost link between the scarce little pouched mammals of the time of the dinosaurs and these numerous and relatively well developed forms is probably in some locality of the preceding geological age as yet unknown to us. It seems reasonable to suppose that this fauna assembled in America about the end of the Cretaceous by migration from a country where future exploration may yet reveal the steps in its intermediate development.

There was, of course, no such specialization among these Eocene mammals as we observe in the class in later times. They were all very generalized types — built upon the same general plan, and, although Cope found ninety-three species and some of the main divisions of the class, such as Carnivora, Herbivora, Insectivora and Primates, they are not yet distinctly separated by the long process of adaptive modification as we now know them. If they converge to a common order, the Insectivora, in the Cretaceous, at the beginning of the Tertiary the primitive representatives of modern orders still approached each other so closely that if they were contemporary with us we would probably group nearly all of them in the same family. It is from an evolutionary point of view that the Tertiary mammals are especially of interest to us, and it is merely the aim of this article to review in an elementary way a few of the earlier types which have been studied by Leidy, Cope, Marsh, Osborn and others in their relation to those of the present day.

In Eocene times, the earliest period of this age, there prowled in the waters along the southern coast of our continent a huge shark, *Carcharodon megalodon*, the specific name being derived from the great size of its triangular teeth, which are in some cases as large as a man's hand. The jaws of this monster were four to six feet across, and its length was probably from fifty to seventy feet. Sharing in the rule of the waters with this shark was the *Zeuglodon* (Ζεύγλη, a yoke; ὀδους, tooth), another predaceous creature of great size, deriving its name from a peculiarity of the teeth, each molar being composed of two separate fangs united by a crown, while conical teeth were set in the front of the long and narrow jaws. As the vertebræ of this animal were some of them eighteen inches long and twelve inches in diameter, and as nearly seventy feet of the vertebral column have been found in place, the entire body-length must have been more than seventy feet. These are remains of whale-like proportions, and, although they have been numerously found in the Southern Eocene, and it is probable that their range was quite extensive, none has as yet been discovered which might give evidence of a transformation of these primitive cetaceans linking them more closely to our modern whales, or which would connect them with any known form of the Age of Reptiles. Going back of this stock, similarities in the form of the body suggest an alliance with the ichthysaurs, but the history of our marine mammals must be constructed upon a more reliable foundation than that of similarity of body form. These aberrant mammals cannot be brought into a single group, but belong to series not closely related. It is probable that the whales, the sea-cows and the seals originated from very old and separate land-dwelling mammals, the different branches becoming adapted independently for an aquatic life. We recognize here an example of the phenomena of convergent adaptation, the influence of a similar mode of life bringing about changes in these marine forms along converging lines from divergent land-dwelling origins.

The early Tertiary progenitors of the now widely distinct orders of land mammals were probably all five-toed Plantigrades with the tuberculated molars of Omnivora. There was as yet very little modification among them for any special kind of food or for differing climatic and physical conditions. The incisors were not specially adapted for grass cropping, nor the tuberculate molars for either flesh or herb eating; the feet were neither clawed and retractile like those of the cat, nor hoofed like those of the later deer and horse families. Therefore we see no particular adaptation of the feet for seizing prey, climbing, or running; the type is a synthetic one — a stem — which is later, under changing environment and adaptive specialization, to unfold a tree of separate and separating branches.

One of the most fascinating chapters for study in tracing these fossil relationships is furnished by the branching from this generalized stock of the hoofed animals, which constitute the most numerous and comprehensive group of larger mammals, including those formerly classed as Ruminants, Solidungula, and all of the Pachyderms with the exception of the Proboscideans. To the reader not already acquainted with the outline characteristics which distinguish this order it will be sufficient for this article to say that the Ungulates walk upon the extremities of the toes, the third phalanx of each digit being encased in a nail so modified as to form a hoof. The first digit (thumb) is always obliterated, therefore the number of developed digits in the true Ungulate never exceeds four. The limbs are used only for locomotion, never for prehension, and clavicles are wanting. Although the primitive Ungulates had the tuberculated molar teeth of Omnivora (bunodont) like a few living forms, as the pigs, the typical molar of living members of the order is massive with a broad, flat crown (selenodont), suited for crushing and grinding vegetable food. The teeth are usually well developed, but incisors may be entirely absent from the upper jaw, as in the ox, sheep, and deer.

At the very lowest strata of the Tertiary is first found a group of animals, the Condylarths, which is considered to represent very nearly the central protungulate type from which all hoofed animals are descended. The best known genus in this ancient order is *Phenacodus*, a skeleton of which (*P. primævus*) was found by Dr. Wortman in the Lower Eocene of the Big Horn Basin, Wyoming, and described by Cope, who regarded it as representing the form from which developed the hog, hippopotamus, deer, camel, rhinoceros, and all other hoofed animals. This very generalized mammal was about the size of a sheep. It was digitigrade about as the tapir, and had five fingers and five toes provided with nails which were flat and could neither be called claws nor hoofs. It had the full complement of teeth (44) which were bunodont, indicating an omnivorous habit. The sides of the body were lank, back arched, tail long, and hind limbs longer and stronger than the fore — cat-like characters linking it to the primitive clawed stem from which the two great divisions of mammals — the flesh eaters (Carnivora) and the herb eaters (Ungulata) — sprung.

While *Phenacodus* was much too large to be in the direct line of the ancestors of the horse, its feet give us a very good idea of the character of those of the hypothetical five-toed progenitors of the beginners of this series. The first undoubted mammal of the equine evolutionary line appearing in North America is the Eohippus, which is a little animal no larger than a small fox. From this four-fingered and three-toed ancestor we have an unbroken line, with intermediate steps in development, through the stage with three fingers and three toes and that with one functional (the third) and two rudimentary (the second and fourth), until we reach the genus *Equus* with the lateral digital columns entirely wanting and nothing left of the lateral metacarpals and metatarsals but the two rudimentary or splint bones, which is the foot structure of our modern horse, ass, and zebra. This evolution of the horse family took place in America between the Early and Late Tertiary, during the elevation of the continental land surface, and was accompanied by a coördinating increase in size and adaptive modification of the animal to its changing conditions of life.

Related to the horses and radiating from the same central *Phenacodus* type we have two other living odd-toed (perissodactyl) families, represented by the rhinoceros with three fingers and three toes, and the tapir with four and three respectively. During most of the Tertiary rhinoceroses were common beasts in North America as well as in the Old World, but before its close they had become extinct in America, while in the Old World they have survived to the present time. The tapirs began in the Early Tertiary and exist to-day in South America and India; they are the survival of a very ancient ungulate type, related to the extinct *Coryphodon* and *Palæotherium*, the latter appearing to have agreed with the modern tapirs in possessing a lengthened and flexible nose, a sort of trunk, suitable for stripping foliage. Although the tapir has four fingers, the axis of the arm passes through the third, and the number of toes is three. Thus it exhibits in the fore limbs the relation of parts, and in the hind limbs the structure as well as the relation of parts which distinguishes the odd-toed from the even-toed branch of the Ungulates.

In the last named section the toes are two or four in number (artiodactyl), and the axis of the limb instead of passing through the third, as in the Perissodactyla, passes between the third and fourth, which have a form in ruminants which suggests the term "cloven-foot." We observe, then, that in the first sub-order support is centred in the third toe, which is the most highly developed, while in the second the support is equally divided between the third and the fourth, which have an equal development. The artiodactyl division of the Ungulates is of interest in being the most numerous of the larger mammals now living, including all the Ruminants and the pigs and hippopotami. This division was well represented during the Tertiary, the earliest forms apparently being the ancestors of the pigs, to which the hippopotami constitute a side group. The characteristic feature met with in these primitive forms is the elevation of the enamel of the crowns of the molar teeth to form tubercles, while in the Ruminants these elevations are flattened and take the form of crescents. These, with correlated features, furnish us two divisions of the Artiodactyla, the Tuberculate Toothed (Bunodonta), and the Crescentic Toothed (Selenodonta), the former including the pigs and hippopotami, of omnivorous habit, non-ruminating, and having a simple stomach; the latter the very large group of Ruminants which are herbivorous, and have the complex stomach. There were no Ruminants in the Eocene, and throughout all of the Tertiary bunodont dentition was common in the Artiodactyla. But at the present time, after setting aside what has become the very subordinate group containing the pigs and hippopotami, all the remaining pair-hoofed mammals belong with the ruminating Selenodonts.

Unique in several respects among existing Ruminants is the family *Camelidæ*, containing the camels and llamas, which, in view of their cushion-like feet, have been placed by zoologists in a distinct group — the Tylopoda. In addition to this peculiarity the upper incisors have not entirely disappeared as in other ruminating animals, and the skull does not bear horns. The occurrence of llamas and camels in two such widely separated regions of the earth as South America and Asia remained unexplained until the distinct recognition of the ancestors of this family in North America in an area ranging from the Upper Eocene to the Upper Miocene. It would appear from these discoveries that the family was evolved during this time from primitive Artiodactyls, and that by the Pliocene the fully differentiated camel had reached

India by way of land connection then existing in the north between North America and Asia. At the beginning of that period an upheaval occurred uniting North and South America by the Isthmus of Panama, over which wandered southward the ancestors of our present South American llamas, while by the close of the Pliocene all of the members of the family in North America had become extinct.

The *Cervidæ*, or true deer, with their solid antlers (cervicorn) first appear in the Middle Miocene of Europe, and somewhat later in the same period in North America. The more specialized Hollow-horned Ruminants (cavicorn) are also first found in the Miocene of Europe, represented by the antelopes, and have attained their highest development in our modern sheep and oxen. As to the precursors of our oxen we have a very indefinite record. So far as known they first appear in the Lower Pliocene of India (Siwalik Formation), and before the close of that period they are found in both Europe and North America. We have also in the Siwalik Formation the first appearance of the bison, and remains of the extinct forerunners of the North American species (*Bos americanus*) occur in the Upper Pliocene of the United States. The *Bos bonasus*, or European bison, a few specimens of which still survive in Europe, and in the United States at the New York Zoological Park, ranged over most of Europe during the Pleistocene period. This species is the nearest living relative of the American bison, and has been somewhat confused with another species — *Bos primigenius* — which was the wild progenitor of some of our existing breeds of domestic cattle, but which is now extinct.

The giraffe occupies a rather isolated position in the ungulate series; while it has the paired hoofs and complex ruminating stomach of other members of the Artiodactyla, the frontal armature consists of two bony prominences covered with a hairy skin which are not shed periodically, as in the deer, and are never covered with a horn sheath, as in the oxen. With these features and the long neck and forelegs and the peculiar, leopard-like markings, we have altogether an animal of a very unique type. It is probable that the giraffes of Africa are immigrants from the south of Europe. Further tracing leads us to an animal of the early Pliocene inhabiting Southern Europe and Asia, with a type of structure very much like that of the giraffe and associated with genera which seem to have connected it with the primitive Hollow-horned Ruminants. The only known remains of this animal are very fragmentary and do not include the top of the skull, therefore it is not yet certain whether it had the same character of horns as the existing giraffe. Its equally long neck and limbs, with the similarity of the teeth, however, clearly define its affinities to the giraffe family.

Among the mammalian remains recovered from the Miocene strata of Central Europe and India are those of the Dinotherium, a huge animal with a remarkable downward curvature of the end of the lower jaw, from which projected two long tusk-like teeth directed downward and backward. From the points of these teeth to the top of the cranium was five feet, and the skull, which measured three feet in length, gave evidence of having had attached to it an elephant-like proboscis. This animal was among the earliest of the Proboscideans, but with its completely lost upper incisors and the peculiar conversion of the lower ones into down-curved tusks, it cannot be regarded as an actual link between the elephant and its primitive ancestors; the mastodons occur in almost the same geological horizon with the dinotheres, and from this on *Dinotherium*, *Mastodon* and *Elephas* successively exhibit the change of the incisors into the characteristic elephantine tusks, with the acquirement of the prehensile proboscis. In relation to the tusk development of our modern elephants, it is interesting to note that some of the Miocene mastodons exhibit an upper and a lower pair of constantly growing incisors, while in the Pliocene most of the species have so far advanced as to be entirely destitute of lower incisors, and the upper ones are tusk-like. In the elephant, as is well known, we have only the upper incisors retained, and these are constantly growing and fully developed into tusks.

As before mentioned, the forerunners of the Hoofed Animals, the Condylartha, of which the *Phenacodus* is the best studied genus, have many carnivorous characters, and it is difficult, among these earliest Eocene mammals, to differentiate between the beginnings of the hoof-bearing and claw-bearing groups. Specialization progressed during this period, however, and before its close Ungulata and Carnivora had become well defined both in America and Europe. The most primitive Carnivora of the Eocene are usually placed in the sub-order *Creodonta*, an extinct group of especial interest in possessing characters almost identical with those of the Condylartha. Their dentition differs from that of the true Carnivora in the complete absence of the carnassial tooth, or in its development from other teeth of the series. In the modern flesh eaters the carnassials are the fourth upper premolar and the first lower true molar, which have high, strong crests, working against each other and adapted for cutting. At the beginning of the Mammalian Age the Creodonts are already numerous, and, increasing in variety throughout the Eocene period, seem to represent more than any other fossils thus far discovered the central stem from which most all of our modern mammals have branched. But during the Eocene this ancient stock became more and more crowded in the struggle for existence by the increasing and more formidable true carnivores until by the close of that period they had gone down under the law of survival and entirely disappeared. The seven families of the living land Carnivora include the bears, raccoons, dogs, civets, the mustelines, cats and hyænas. Of these the raccoons are peculiar to America, and the civets and hyænas are found only in the Old World, while the four remaining families are found in all the continents except Australia, in which continent Carnivora are not native. The earliest known ancestors of these families were of a very generalized type, but most of the fossil true Carnivora can be assigned to one or another of them, while from the Middle Tertiary on the ancestral lines can be more or less directly traced. As to the origin of the sub-order *Pinnipedia*, palæontology has as yet furnished no definite clue. Fragmentary remains characteristic of the seal have been obtained from the Pliocene of Europe and North America, and it is known that by this period they had already become well specialized to their aquatic mode of life. It is quite possible that their early Tertiary ancestors were lake-dwelling animals which eventually wandered into the sea.

The ancient order of Insectivora is of interest in representing more nearly than any other living order the primitive stock from which other mammals have descended, and it is probable that the little insect eating mammals are but slightly altered survivors of some of the earliest placentals. At the dawn of mammalian life this group was of much more importance than now, but they have progressed but little, and their competitors among other mammalian orders have outstripped them in the struggle for survival. Therefore the Insectivora are a disappearing group which, to escape the severe competition with the better equipped, have taken refuge in peculiar modes of existence or methods of defense, as the earth-burrowing mole, the nocturnal and easily concealed little shrew, and the hedgehog with its spiny coat serving as a protective armor. Some of the extinct insectivores and lemurs apparently constitute a link between the Insectivora and Primates. Of the latter order the lemurs of Madagascar are the most primitive, the smallest of monkeys, the little, squirrel-like marmosets, being nearest allied to them. The earliest lemurs, so far as known, lived in Eocene times in Europe and North America, while at the present day the majority of these representatives of the monkey tribe are to be found in that common haunt of weird and archaic beasts, the impenetrable forests of Madagascar.

The study of the successive predominance and subordination in the struggle for existence, up through the respective geological domains of the marine invertebrates, fishes, reptiles and mammals, brings to mind the question: What are the forces working through these inconceivably long reaches of time that build from insignificant beginning a faunal empire, which in its turn is crowded out by the ascendancy of another? Darwin undertook to solve the problem by showing that it results from extermination according to a standard of fitness; nature's selection for survival of such individuals of a species as possess variations better fitting them to a changing environment. It is not for this article to comment upon the arguments that have gathered around this thesis; as to descent we cannot in this day speak of it as a theory; descent is now accepted by science as a fact — a law, and is no longer a theory. But the doctrine of descent, or organic evolution, was pre-Darwin; Darwin brought to its support the results of his prolonged study and observation, and, while recognizing other influences, made clear the far-reaching force of natural selection as a cause. How far this may be accepted in explaining descent remains debatable, and, essentially, the deeper we go into the sciences relating to the subject the more competent we become to weigh the evidence and reflect critically upon the arguments for or against Darwin's conclusions.

In closing this brief survey of the rise of the mammals, however, certain prominent influences for their success should be mentioned. Though the members of the class first known to appear were so insignificant in size and numbers as compared with their huge saurian contemporaries, in two respects they were superior; in limbs and feet with a joint construction mechanically advanced, and in a superior brain. These were the prime winning factors that preserved these little creatures for their triumphant destiny, and which were further and further elaborated upon through vast stretches of geological time, until at the beginning of the Cenozoic era we have, with the receding of the reptiles, the dawn of a new life — the Age of Mammals.

While there has been much branching and specialization to peculiar modes of life among the mammals, some surviving, others becoming extinct, the elements of supremacy have remained those of superior structure and intelligence, which in the beginning gave them their advantage over the reptiles, and which have reached their highest expression in man, giving him, in turn, dominion over all the animals of the earth.

MINUTES OF THE INSTITUTE.

November 4, 1909. — Regular monthly meeting, with Vice President Henry L. Broomall in the chair. The usual monthly reports of the officers and committees were received. Under the head of scientific business Robinson Tyndale presented two specimens of basalt rock from near Haida, in Austria. These rocks are six sided, similar to the rocks of the Giants' Causeway. The outcrop covers about an acre, some of the stones being two or three metres long. Of late years much of the stone has been removed for use as posts, curbing, etc. Albert S. Barker exhibited a number of microscopic specimens of various kinds. After discussion the meeting adjourned.

November 11, 1909 — Adjourned meeting. Lecture, "The Indian No Problem," by General R. H. Pratt, U. S. A., retired.

December 2, 1909. — Regular monthly meeting, with President T. Chalkley Palmer in the chair. The usual monthly reports of officers and committees were received. Horace G. Worrall, Alpheus W. Moon and General R. H. Pratt were elected to membership. Mrs. A. Lewis Smith presented to the library a set of "Annals of the American Academy of Political and Social Science." Under scientific business a number of specimens were presented to the museum. Among other things Albert S. Barker exhibited an ear of Indian corn which showed the staminate flowers to have developed on the same spike as the pistillate flowers in which the grain had matured. It was suggested that this was a case of revision to an ancestral form. After general scientific discussion the meeting adjourned.

December 9, 1909. — Adjourned meeting. Lecture, "Change of State of Matter," by Dr. Harold C. Barker, of the Department of Physics, University of Pennsylvania. The lecture was accompanied by many interesting experiments.

DECEMBER 23, 1909. — Adjourned Meeting. Illustrated lecture, "Cement; Its History, Manufacture and Use," by Prof. Claude Berry, of the Department of Civil Engineering, University of Pennsylvania.

JANUARY 6, 1910. — Regular monthly meeting, with Vice President Henry L. Broomall in the chair. Reports of committees and officers and miscellaneous business. The scientific portion of the meeting was devoted to a lengthy discussion upon astronomical subjects, covering comets, central forces, spectroscopy, etc. Meeting adjourned.

JANUARY 13, 1910. — Adjourned meeting. Lecture, "Animal Behavior," by Dr. H. G. Kribbs, of the University of Pennsylvania.

JANNUARY 27, 1910. — Adjourned meeting. Lecture, "Types of Vegetation in North America," by Dr. John W. Harshberger, of the University of Pennsylvania.

MINUTES OF SECTION A.

NOVEMBER 18, 1909. — Miscellaneous scientific meeting, with presentation of mineralogical and natural history specimens. Among other things, Dr. B. M. Underhill presented a specimen of an interesting parasitic worm, *Echinorhynchus gigas*, order Acanthocephala. This worm is interesting from the fact that it has no digestive tract, but gains nutriment by absorbtion through the body wall. The young worms locate in the larva of the May beetle. The latter are eaten by hogs, and the worms become parasitic in that animal.

DECEMBER 16, 1909. — General microscopic meeting. T. Chalkley Palmer exhibited under the microscope bacteria from the human mouth and explained the principles of side illumination and dark background by which they were made visible by a comparatively low power. Albert S. Barker exhibited lantern slides of the winged seeds of *Paulownia imperialis*. The usual discussion and exhibition of miscellaneous subjects followed.

JANUARY 20, 1910. — Albert S. Barker exhibited under the microscope *Globigerina* mud from the depth of 119 fathoms; also a number of other microscopic objects. Dr. J. C. Starbuck exhibited a species of scale which was found infecting a box of oranges shipped from Florida. William R. Newbold, Jr., showed a number of seeds arranged like strings of beads, the work of the natives of Panama, and used as curtains for doors, etc. He also spoke of the crocodiles found in that region, and said that in the heads of two specimens which he had examined the lower teeth protruded through the upper jaw and produced an elevation of the flesh. Henry L. Broomall mentioned the derivation of the word *alligator*, showing its descent from the Spanish *el lagarto*, the lizard, and the subsequent rehabilitation of the word in the modern Spanish *aligador*.

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PROCEEDINGS

OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. V, NO. 3 APRIL, 1910

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PHYSICAL CURVES.

BY C. M. BROOMALL.

To the mathematician the word *curve* means usually a sort of visualization of an analytical relation between certain quantities. In other words, he knows that every equation between two unknown quantities can always be represented by some form of plane curve. If his mind is algebraically inclined he will consider the curve merely as an aid to a clearer understanding of the relationship expressed by the equation. If his bent is toward geometry he will probably consider the geometrical curve as the principal thing, and make use of analysis to determine the properties of the curve, as for instance, its tangents, normals, curvatures, maxima, minima, etc.

With one or the other of these views of the subject the mathematician is usually satisfied, and the matter might rest here were it not for a worker in another branch of science. The student of physics in the examination of various natural phenomena finds much use for the mathematical conceptions of his co-laborer. He finds that many of these more or less imaginary conceptions of the mathematician have a real existence in the world of physical facts. He finds that there is a broad overlapping boundary between the two branches of science where each aids the other. In this connection it is hoped that a cursory glance over this common field may not be devoid of interest.

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By physical curves, as here mentioned, are meant all those mathematical curves which are found to be closely related to certain physical phenomena. It is indeed surprising to note how many such phenomena may be studied by the aid of a few mathematical conceptions. Let us consider some of the commoner relations one by one.

The Ellipse. — The principal occurrence of the ellipse in physical phenomena is as the type of planetary motion. The orbits of the earth and other planets, as well as the orbits of the periodic comets, are all ellipses, the sun being at one of the foci of the curves. Any body under the influence of a central force which varies inversely as the square of the distance from the centre of force will describe an ellipse. In this case the centre of force is at one of the foci of the curve. If the body moves under a central force which varies directly as the first power of the distance, then likewise is an ellipse described, but in this case the centre of force is at the intersection of the two axes of the curve. This is the law of molecular physics and is of great importance in optics, acoustics, etc.

The Cycloid.—The cycloid in its simplest form is the curve described by a point on the circumference of a circle which rolls along a given straight line. In its broader sense the cycloid may be defined as the curve described by any point on the radius of a circle, or on the radius produced, when such circle rolls upon a straight line or upon or within a circle. It is seen from this that the very mathematical conception of the cycloid is physical in its nature. It has, however, certain very real physical relations, two of which are indicated by the names brachistochrone and tautochrone, sometimes applied to it. The first of these, as its derivation indicates, is the curve of quickest descent. In other words, if we have a body constrained to fall down a frictionless curve shaped like an inverted cycloid, for example, a wheel or marble rolling down a track of some kind, it will take less time for the body to roll down this curve from one level to another than down any other form of curve or straight line. The other name for the cycloid, the curve of equal times, means that if a pendulum bob is constrained in some way to vibrate in a true cycloidal curve, the vibrations of the pendulum will be isochronous no matter what the amplitude of vibration. It is commonly said that this is so of the ordinary pendulum, but this is not true, although a very close approximation is reached when the angle of vibration is small.

The Spiral.—The spiral is the curve described by a point which while revolving around a fixed centre continually approaches or recedes from that centre under some given law. There may be, of course, a number of different kinds of spirals. One of the most interesting of spirals is that which would be described by a body moving under a central force in the presence of a resisting medium. In this case the body would gain in lineal velocity and slowly wind in to the centre of force. At one time it was thought that Encke's comet, one of the periodical comets, was showing an unexplained increase in velocity and was moving in such a spiral path. It was therefore assumed that the presence of a resisting medium in planetary space was indicated. Later observations, however, do not seem to have confirmed this theory.

The Helix.—This curve differs from the preceding curves in that it is a curved line in three dimensions instead of two. It is such a curve as is described by a body revolving in a circle at the same time that the plane of the circle moves perpendicularly to itself. The path of the end of a propellor blade illustrates this motion. The helix is supposed to be indicative of the form of wave met with in the luminiferous ether in circulary polarized light.

The Sine Curve.—The sine of an angle is equal to the vertical projection of a moving radius in a circle whose radius is unity. By sine curve is meant the curve which would be plotted by setting off equal angles along a horizontal line and at each point erecting a perpendicular equal to the sine of the corresponding angle. The angle increases from 0° to 360° and so on through successive cycles, while the sine passes through various values between plus and minus one as its limits. The result of plotting such values of the sine in the manner described is to produce a wavy line called the sine curve. The sine curve is typical of almost every kind of vibrational motion met with in nature, the ordinates representing displacement and the abscissas representing angle, time or length as the case may require. Another name given to the curve is the harmonic curve, from the fact that a vibrating elastic string or cord, as for instance, a violin string, swinging back and forth, in some cases takes the form of an almost perfect sine curve. Although the vibrations in any particular phenomenon may not be truly sinusoidal, it has been found possible by assuming the superposition of a number of sine curves of varying amplitude and period, to exactly represent the resulting motion. This has given rise to a branch of mathematics known as harmonic analysis. This combination of a number of sine curves is shown very nicely in the case of the violin. In this case, for a given note, the string vibrates powerfully back and forth at a rate corresponding to its pitch. This is the fundamental vibration. At the same time the string is vibrating weakly back and forth in 2, 3, 4, 5, etc., segments. These faint vibrations are called harmonics, and their effect added to the fundamental note is to produce the peculiar timbre of the violin tone. Each vibration in itself is a perfect sine curve, while the actual resulting motion of the string is more or less "writhing" in character.

In the field of electricity the sine curve is likewise of great application in analysing and examining the phenomena of alternating electric currents.

The vibration of the perfect (cycloidal arc) pendulum, is often termed harmonic, as a pen or marker fastened to the bob would describe the sine curve on a piece of paper moving uniformly under it at right angles to the plane of vibration.

The same term is also applied with approximate accuracy to the motion of the common pendulum. The motion of the perfect pendulum is the same as the back and forth motion of any given point on a vibrating cord when the wave form is a true sine curve.

The Parabola. — The physical relationships of the parabola are probably more numerous than any other curve, and only a few of them will be mentioned. A projectile in a vacuum, shot forth at any angle from the vertical, describes in its flight a parabola. In actual practice, as for example in the case of projectiles from cannons, issuing forth with extremely high velocity against the resistance of the atmosphere, the curve is modified by such resistance. It is then no longer a true parabola, and becomes what is known as the ballistic curve. This curve is to a large extent empirical, although it has for its basis the parabola as modified by air resistance. If a series of projectile parabolas are drawn, in which the projectile is assumed to start with equal velocity and at different angles from the same point, there will be formed what may be called a family of projectile parabolas. In this case it can be shown that the envelope of the family of curves, that is, the curve to which all the parabolas are internally tangent, is a parabola itself.

Closely related to the projectile curves is the curve assumed by a jet of water issuing out of the side of a reservoir or tank. In this case, if atmospheric friction is neglected, the curve of the issuing jet of water becomes a parabola.

As mentioned elsewhere in speaking of the catenary, the parabola is that curve assumed by a flexible body loaded uniformly along the horizontal.

Again, consider a simple beam, such as is used in building, carrying a load uniformly distributed along the horizontal. At every point in such a beam there exists a tendency to break it transversely, which tendency is measured by what is called the bending moment. If the value of this bending moment is plotted at various points in the length of the beam as vertical ordinates, the resulting curve will be a parabola.

Another physical application of the parabola is found in its use as a reflector to concentrate parallel rays of light to a focus, or vice versa. It is a characteristic of the parabolic reflector that parallel rays of light striking its surface in a direction parallel to its axis are concentrated at a single point called the focus. Conversely, light from the focus is reflected forth in a parallel beam. It is interesting to note that a related phenomenon exists in the case of the ellipse. Thus, if a light is placed at one focus of an elliptic mirror, the rays after reflection will be concentrated again at the other focus. In the case of the hyperbola, with the source of light at one focus, the beam of light projected forth after reflection will be divergent, but the directions of its rays produced backwards will meet at the focus of the conjugate hyperbola. These facts, of course, are all due to the characteristic of the conic sections that the lines from a given point to the foci make equal angles with the tangents.

Another form of the parabola, known as the rectangular parabola, whose mathematical characteristic is that the product of the ordinate and the abscissa at any point is constant, is met with in the phenomena of capillarity. If two glass plates, with two of the edges together and their planes making a slight angle, are dipped in water with the joining edge vertical, the water will rise up between the plates to a distance dependent upon the width of the opening. In this case it will be found that the surface of the water assumes the form of a rectangular hyperbola, whose axes are respectively horizontal and vertical.

The Catenary. — This is another one of the curves which, like the cycloid, is physical even in its mathematical derivation. It is that curve which is assumed by a perfectly flexible body of equal weight per unit of length, as for instance a heavy rope or chain, when suspended loosely between two points. This curve, it may be noted, is not the curve assumed by the cables of a suspension bridge, as in the latter case the roadway of the bridge and its various loads are usually more nearly distributed uniformly along the horizontal than along the curve. As mentioned elsewhere, if the load were uniformly distributed along the horizontal and the cables of the bridge possessed no weight, then the curve assumed would be parabolic. But the cables possess weight uniformly distributed along their length and the resulting curve assumed by them is therefore neither a catenary nor a parabola. As examples of catenaries may be mentioned the ordinary electric light wires, telegraph wires, etc., which hang in true catenary curves, and of which the tension at any point can be exactly calculated.

The Logarithmic and Exponential Curves.—Logarithms were originally invented solely for the purpose of shortening the ordinary processes of multiplication, division, etc. The natural numbers and their corresponding logarithms when plotted as abscissas and ordinates constitute the logarithmic curve. Although in origin logarithms are anything but physical, yet the laws underlying logarithmic equations (and the closely related exponential equations) have important physical relations. The logarithmic and exponential functions have as their foundation an equation in which one of the variables enters as the exponent of a constant base.

An equation of this form expresses what is known sometimes as the compound interest law, as in a modified form it can be used for the calculation of principal at compound interest — a very materialistic relation between mathematics and physics.

If the exponent in the exponential expression is negative, and the equation is properly modified, there results what is known as Newton's law of cooling, expressing the temperature of a cooling body at any given time. Likewise, the law of chemical reactions is expressed by an exponential equation with negative exponent. Other examples of the same relation might be mentioned.

These are all matters concerning quantities which increase or decrease according to the magnitude of the quantity itself. Thus, the principal at compound interest increases at a rate proportional to the principal itself, since interest is added to principal; the rate of cooling of a body becomes less as its temperature differs less and less from the surroundings; the rate of chemical change becomes slower as there is less substance left unchanged. The applicability of an exponential equation to changes which follow this law is well known to those familiar with the calculus.

If we have an exponential equation with negative exponent containing the square of the variable, the equation, properly modified, represents the probability curve, expressing the law of the facility of error. In other words, the ordinate to the probability curve at any point is a measure of the probability of committing a given error in a series of measurements, observations or trials, and the area of the curve between proper limits determines the probability that an error shall not exceed a certain amount. The curve is the basis of the method of least squares by which the most probable value of a given quantity is deduced from a series of observations, a method of immense service in geodetic, astronomical and other measurements.

In the foregoing the effort has been made to mention a few of the so-called physical curves and their characteristics. The list is very incomplete, and many more examples could be cited. These which have been given, however, it is hoped will serve to suggest to the reader further relationships between mathematics and physics of similar character.

In conclusion, it is interesting to pause for a moment and consider why there should exist this common boundary region between mathematics and physics. We have here two branches of science which have developed more or less independently side by side. One is what may be termed a mental science, and might have developed along any line consistent with the fundamental conceptions imagined by its creators. The other branch, physics, is a science of discovery and concerns natural laws beyond the control of man. If, however, a comparison be made between these two lines of investigation, the reason for the existence of the common boundary region is easily found. The fundamental concepts of mathematics are practically only two, namely, magnitude and direction. The former includes all variations of size under the given law in question, the latter all matters of composition and opposition, positiveness and negativeness, etc. These fundamental concepts underlie all branches of mathematics. In the field of physics, it is found that all force, motion, energy and such other entities as are met with in nature, are governed by laws which group themselves around two fundamental ideas, first, that these quantities vary in magnitude in certain determined ways, and second, that they act sometimes in one direction and sometimes in the other, sometimes in conjunction with one another, sometimes in opposition, sometimes inward, sometimes outward, etc. In other words, again we have the same two concepts of magnitude and direction. Hence, with identical fundamental ideas in both mathematics and physics, it naturally results that many identical relations should have been evolved in one case and discovered in the other.

THE MECHANISM OF DIATOM MOTION.

BY T. CHALKLEY PALMER.

Previous papers in these PROCEEDINGS have dealt with the general nature of diatom motion, and the endeavor has been to present clearly the reasons for thinking that the phenomenon is an outcome of protoplasmic work, and in no degree explicable on any "theory of osmosis." For the rest, it remains to learn if possible the mechanism by means of which the protoplasm acts upon its surroundings to push the diatom along. Protozoa and the spores of algæ swim through the water with the aid of obvious cilia and flagellæ. Rhizopods crawl along solid surfaces by alternately expanding and contracting portions of their naked sarcode in different directions, so showing the phenomena of the pseudopodia. These things are easily observed, but the locomotion of the diatom is another matter. Immersed in its native element, and in the full enjoyment of health, the living substance, enclosed in a beautiful box of opal, ordinarily reveals under the best lenses no external organs whatever. Yet, as we have seen, the motion is often of a stubborn and strenuous nature. Mechanism of some sort there must be.

First of all, it is to be said that both vibrating cilia and pseudopodia have been alleged in certain cases. But it is now universally agreed that the observations leading to the notion of cilia (where there were any real observations) are one and all capable of other interpretations, and that the deductions in this direction are due to a misconception of fairly elementary facts. According to a wide concensus of opinion, cilia do not exist among diatoms; and in case of many of the larger motile species, it is impossible to see how typical cilia could exist. As to pseudopodia, the matter is not quite capable of such crisp statement. But it may still be said with rigor, that visible pseudopodia, like those of the rhizopods, have not been seen operating in the living and moving diatom.

In order to make what follows endurable for the reader who is not a specialist in diatoms, it will be necessary to recall the main features of the diatom's structure. The living substance, consisting of protoplasm with a nucleus, and enclosing chromatophors and vacuoles, etc., is enclosed in a peculiar, heavy, silicious box. This box is constructed on the plan of a pill-box with its overlapping lid. The bottom of the box and the top of the lid are alike known as valves. The sides of the box are composed of two bands, one outside the other, called girdles. The whole is known as a frustule. These frustules vary endlessly in shape in the different species and genera, though always of the described construction. Also, they may grow in colonies, filaments, etc., or exist as isolated individuals. It is the isolated species that mainly concern us. Outside the silicious box is a layer of jelly, variable in depth even in the same species, called the coleoderm. It is ordinarily invisible in water, even when it has assumed a very considerable bulk. It is not protoplasm, but an excretion. Bismark brown has much affinity for it, though staining protoplasm with difficulty. Eosin, on the other hand, prefers the protoplasm. By success in staining with these two, fairly sharp delimitation may be had, at least when the coleoderm is stiff enough to keep its shape under treatment. This is not always the case. This coleoderm is of importance in what follows. To return to the valves. A very large number of species have valves more or less elliptical in shape, giving the frustule somewhat the aspect of a boat. These are the naviculoid diatoms. Their valves show conspicuous axial lines running from each end toward the middle. These lines are known as raphes. The raphe has been shown to be a real cleft through the silicious wall, though so narrow that the thinnest bacteria can scarcely pass it, but in the larger species not too narrow for the same bacteria to insert their very attenuated flagellæ. Here, then, is one opening through which the internal protoplasm may pass to operate upon the environment directly. Now it is precisely the species provided with this raphe which exhibit the liveliest motions. It is true that a number of species not provided with a technical raphe also move more or less, each after its own fashion ; but those others have something just as good, and in fact something quite of the same nature. Such is *Nitzschia*, with two longitudinal keels, each furnished from end to end with the smallest imaginable cleft. Such also is *Surirella*, with four keels, each with its very narrow cleft. These move with vigor. *Campylodiscus* has similar clefts near the edges of its bent discs, and it goes along haltingly. *Eunotia* has short raphes at its corners, and here again is power of motion with peculiar features. *Synedra*, very long and narrow, has nothing but dot-like openings at its ends, and can rear itself on end from a perfectly flat surface, but no one has claimed for it actual power of locomotion. *Tabellaria* and a multitude of others, without visible openings classifiable as even rudimentary raphes, have not been seen to move at all. We may therefore be certain that the internal protoplasm acts directly or indirectly through the raphe or its equivalent when pushing itself along. No raphe, no motion ; no motion, no raphe. Therefore it is that students of diatom motion have generally confined themselves to the observation of the naviculoid species, more particularly to those larger forms of *Navicula* often classed under the name of *Pinnularia*. The work of Hauptfleisch, however, was not on *Pinnularia*, but still on naviculoid forms, though the raphe was not his principal subject, and as a direct consequence of this circumstance he would seem to have been less fruitful in results than his contemporaries in this study.

Omitting pioneer work, and ignoring mere theories, we may say that direct contributions to our present subject are found under very few signatures.* H. L. Smith,† O.

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* In what follows, reference will be to the papers here cited once for all.

† A Contribution to the Life-History of the Diatomaceæ. Proceedings of the American Society of Microscopists, 1886-1887. A summary of Prof. Smith's views will be found in Van Heurck's Treatise on the Diatomaceæ, English version, London, 1896.

Bütschli,[*] P. Hauptfleisch,[†] O. Müller,[‡] R. Lauterborn,[§] are the principal names.

Hauptfleisch sought to demonstrate by staining methods the existence of fine protoplasmic threads issuing through pores in the valves, penetrating the coleoderm, and resembling in general the threads of protoplasm already demonstrated by Klebs in the jelly-sheath of certain desmids. He laid special stress on the "crawling edge" of the frustule, meaning apparently the angle of the valve between raphe and girdle. This investigator's account is not quite convincing, and his conclusions have so far failed to find general acceptance. In certain important points, indeed, he is manifestly wrong. One is bound to say, however, that a confirmation of the general Hauptfleisch conception would furnish an explanation which is still lacking for certain movements of some species. It is to be remembered, also, that the argument of L. Schütt[||] for the existence of "external plasma" is very cogent, and all the stronger for being based on studies directed to another end altogether.

Prof. H. L. Smith, making use of a device not altogether new, made observations on *Pinnularia* in indigo emulsion. He saw in this way a thick layer of coleoderm upon the valve, and traced a current of indigo particles from the front end of the moving frustule, along the raphe to the forward pore of the central nodule. At this point the minute particles collected into a little ball which rotated rapidly, as if acted upon by a jet of water issuing from the pore. Having reached a certain size, the balls broke up and lengthened into a filament, moving off to the rear at an acute angle with the surface of the valve. Immediately thereafter a second ball began to form at the same place, and the whole process repeated itself continuously. All this is best observed when the diatom is lying on its girdle. The action confines itself to the forward half of each valve. When the diatom reverses its direction of motion, the same phenomena are observable in the other half of each valve, the motion of indigo particles being in the reverse direction. So far as appears, Prof. Smith did not draw any final conclusions as to mechanism beyond the suggestion of jets of water issuing from the forward pore of the central nodule. Nevertheless his work, though finding notice mainly in apologetic footnotes of subsequent authors, was the starting-point of later investigations of much interest. His observations have been amply confirmed, except only the existence of rapidly rotating balls; and in this matter I also must confess my failure to see such in moving *Pinnularia*, including *Navicula dactylus*, *N. major*, etc., after following them for long periods of time in ink emulsion. Lauterborn's account of what goes on at the anterior pore of the central nodule seems to me more nearly correct.

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[*] Mittheilungen über die Bewegung der Diatomeen. Verhandl. des Naturhist.-med. Vereins zu Heidelberg. 1891.

[†] Die Ortsbewegung der Bacillariaceen. Mittheil. naturwiss. Vereins für Neu-Verpommern und Rügen. 1895.

[‡] Various papers in Deutschen Bot. Gesellschaft. 1889-1897. O. Müller has been a tireless student of the diatoms, not confining himself to the "Bewegung." In the polemics of the subject he is picturesque and formidable.

[§] Berichte der Deutsch. Bot. Gesellschaft, 1894. Also more elaborately in the magnificent work: Untersuchungen über Bau, Kerntheilung und Bewegung der Diatomeen. Leipsig. 1896.

[||] Centrifugal und simultane Membranverdickungen. Jahrbüchern für Wissenschaftliche Botanik. 1900.

Bütschli, and his brilliant student, R. Lauterborn, also worked with *Pinnularia*, using India ink to outline the invisible coleoderm, and finding that a stream of particles of ink, traveling from the forward end to the central nodule, pushed out finally to form a gelatinous filament. This filament changed its direction of growth when the diatom changed its course, moving always in opposition. Bütschli therefore announced that without much doubt this backward expansion of the jelly filament stood to the motion of the diatom as cause to effect. This filament, he considered, was the equivalent of the gelatinous threads by the protrusion of which certain desmids force themselves along. In place of Prof. Smith's jet of water we are offered a jet of jelly.

Meantime, O. Müller had made minute study of the silicious parts of naviculoid diatoms, at least of the raphe and its terminal pores. He had postulated currents of "plasma" issuing from the cell at the end pores, running along the surface at the raphe, and reëntering the cell at the central nodule. He attributed the motion of the diatom to the reaction between its immediate environment and these external streams of protoplasm. In opposition to Bütschli, he opined that the so-called filament was rather a hindrance than a help, in so far as it was prone to stick to the substratum, and had to be pulled loose or broken off. At first, indeed, he doubted the general existence of such a filament, and thought it a mere evanescent result of a temporary stoppage of the reëntering plasma current, causing a piling up of plasma at the central nodule. At this point Lauterborn entered into the discussion with vivacity, finding the external protoplasmic currents of Müller to be "entirely hypothetical;" and the progress of the controversy, from this on to its comparatively peaceful close, is given at length in Lauterborn's elaborate work already cited as appearing in 1896.

Lauterborn's actual contribution to the subject was of a nature to make an impression. It is bound up with his researches on the contents of the diatom cell and on the construction of the silicious envelope. His work on the cell-contents is of great importance, and he added to our knowledge of the details of the silicious parts of *Pinnularia* and *Surirella*. The raphe of the former had already been demonstrated to be a real cleft, but Lauterborn traced its actual construction almost from end to end, and gave elaborate illustrations of its cross-sections. For *Surirella* he showed finally and beyond the possibility of further cavil the rifts in the keels. The moving *Surirella* had always given every evidence of such rifts, but here they are actually demonstrated. In like manner, in apparent ignorance of the work of Smith, and using what is essentially Smith's method, he made more precise our knowledge of what goes on upon the surface of the valve of *Pinnularia*. The facts observed by Lauterborn, shorn of mere inference for the present, are briefly these: —

Moving *Pinnularias*, when put into India ink emulsion of considerable density, show outside the frustule areas into which the ink particles do not penetrate. In typical instances these areas are of an extent and situation to give the whole diatom, when lying on its girdle, nearly the shape of the figure 8. In this position the silicious frustule itself shows practically as a parallelogram, so that the external substance is seen to be quite deep on each half of the valve, even at times as deep as half the width of the whole cell. This mass of coleoderm, altogether invisible in pure water, is of an apparent firmness in the ink emulsion; but on attempting to apply a stain, it generally sloughs off into a confused mass upon the slide.* Viewed from the valve side, the moving *Pinnularia* shows a stream of ink particles progressing from the front end backward to the central nodule, such as H. L. Smith had described. This stream is about as wide as the hyaline area in which the raphe lies, and the ink particles follow the contour of the swelling coleoderm as this is seen in girdle view. On each side of this hyaline area, over the spaces occupied by the costæ, the coleoderm seems stationary, and ink particles would not appear to cling to it.

Arrived at the anterior pore of the central nodule, the ink particles collect into a single stream, which, curving through a little circle in the neighborhood of this central nodule, straightens out again and pushes away toward the rear at an acute angle with the surface of the valve. This is the Bütschli-Lauterborn filament. These things take place on the forward end of each valve during locomotion. When the diatom reverses its direction, the forward end now becoming the rear end, the same phenomena are seen on the other ends of the same valves, all the streaming being in the reverse direction.

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*I have had repeated confirmation of this statement; and indeed it is a satisfaction to find little to object to in Lauterborn's observations of fact. His apparent belief, however, that the moving Pinnularia ALWAYS shows deep masses of coleoderm, is not in accord with experience, as has been well pointed out by O. Müller.

Thus there would appear to be a stream of adhesive substance over the raphe, bound on each side by coleoderm, and a protrusion of a sticky filament at the place where this stream ends. The stream over the raphe is deep, even to half the width of the cell, and the ink particles do not penetrate it. Lauterborn views this stream and the filament which is an outflow from it as thin coleoderm (gallerte) and would definitely account for the motion of the diatom as being the result of the friction of the raphe-stream and the pushing of the filament upon the diatom's surroundings.

Müller, in taking up the question at this point, welcomes the raphe-stream as a special case of his "purely hypothetical" plasma currents upon the surface of the valve. Lauterborn responds that none of the current is plasma, since it is absolutely invisible in water all the way down to the raphe, and under no circumstances shows the characteristic, protoplasmic, webby structure, a structure visible in the most tenuous rhizopod extensions. Moreover, the filament, which is constantly being shed, is of the same character, and it is inconsistent with all we know of the economy of cell life for an organism thus to be rejecting living substance. But coleoderm does not move itself? True enough. Lauterborn's view is, that the raphe stream and the filament are alike the outcome of a rapid secretion of jelly over the whole surface of the internal protoplasm, most voluminous where the bulk of protoplasm is largest, issuing through the forward pore, along the raphe, and with special force at the central nodule, where the largest mass of all is located. Spirting out here under heavy pressure, just where Müller had placed the reëntering point of his plasma-stream, the main current draws along by adhesion the less vigorous secretions further toward the end. As for any reëntering plasma stream at this place, why should it crawl this far over the long, open raphe, to crowd in at an infinitesimal pore against the solid mass of protoplasm there situated? Not even in the raphe itself was protoplasm to be detected by any device. Furthermore, in a case analogous, that of *Surirella*, all the evidence favors the view that the moving stream in the tube of the long keel is secreted jelly, coleoderm substance in short. In *Surirella*, indeed, according to Lauterborn, we have an opportunity to see the actual limit of protoplasm, which stretches up through the ribs of the keel, showing plainly the webby structure made familiar by the studies of Bütschli, but these reticulations stop at the ends of the ribs, and in the keel itself there is nothing of the kind visible.

The discussion protracted itself with much display of ability on both sides, and ended with these differences of opinion only: The motion of the diatom, according to Müller, is due alone to the raphe-stream, and the raphe-stream is essentially streaming protoplasm, however covered with coleoderm. According to Lauterborn, the raphe-stream is coleoderm altogether, even within the raphe, and the filament into which it finally extends contributes also to push the diatom along.

So, therefore, we have mechanism enough revealed, and agreed upon, though opinions may vary as to some of the details. It is impossible here to give all the arguments pro and con as to the limits of the protoplasm in the species studied. The honors have been thought to be with Lauterborn in this polemic, and certainly his work has done much toward showing the exact status of the whole question. But with all this granted, one does not quite feel that all has been said, or even that everything has been discovered.

The Lauterborn view is not, one feels, absolutely convincing. On at least two points there is good chance for questions.

Lauterborn makes strong assertion to the effect that protoplasm is universally webby in structure, even in the thinnest extensions of pseudopodia, and appeals to Bütschli's work.* But we find in the second figure of the very first plate of Bütschli's drawings an illustration of two pseudopodia of *Gromia* apparently structureless, and on the opposing page these are described in set terms as "hyaline." Moreover, even these pseudopodia are not quite of the tenuosity we may reasonably attribute to a film of flowing plasma no thicker than the flagellum of a bacterium. For no thicker than this would be the stream that fills the raphe of a *Pinnularia*. And even in the somewhat more massive stream within the keel of *Surirella*, it would seem unreasonable to look for reticulated structure so long as the substance is in streaming condition, or expect the thin substance to remain *in situ* during fixing and staining, and reveal a webbiness that is just barely visible even in the most substantial protoplasm in the ribs.

And secondly, Lauterborn necessarily bases himself on the visibility in water of living protoplasm, no matter how tenuous its form. But even the flagellæ of living bacteria, which are much more dense in consistency than streaming plasma, and yet as wide as these currents within the raphe, are at the limit of visibility with ordinary methods of illumination and the best optical aids. Furthermore, recent work at the University of Pennsylvania (the published paper is not immediately at hand) has served to show that the more tenuous extensions of rhizopods have been entirely overlooked, but that their existence can be detected, with all conditions favorable, by an extraordinarily good eye. But these rhizopod extensions are in much better position to be seen than any raphe protoplasm.

The stream within the raphe of *Pinnularia*, and that within the keel of *Surirella*, may alike be protoplasm, clothed indeed with ever-secreting jelly, but still protoplasm. The diatom's protoplasm continually gives off this substance, and the path of the frustule is thinly strewn with it, whether or not it collects into filaments as in *Pinnularia*; and so the living substance protects itself against too rough an environment, making a safe and smooth pathway as it goes, like the snail or slug crawling forever upon its own slime. The raphe stream may be mostly coleoderm in bulk, but one cannot rid himself of the picture of the plasma stream deep within, the living soul of all the mechanism.

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*Protoplasm and Microscopic Foams. English translation. London, 1894.

And however this may be, and in fact whatever Lauterborn's view has of adequacy or inadequacy in explanation of the forward crawling of *Pinnularia*, unfolding streams of coleoderm, however vigorous, seem altogether to fail in clearing up other aspects of the problem, as seen in other species. Even in *Pinnularia* itself, one is unable to see how the frustule that has fallen on its side is ever going to right itself upon its raphe with Lauterborn's machinery. But it does so with some machinery. Not easily nor quickly, nor without a struggle indeed; but in the end the thing is accomplished. It is as if invisible, mysterious tentacles were put forth, which with much effort, and often after a few failures, succeeded at last in rolling the frustule into position. And *Eunotia*, an arcuate parallelopipedon, when fallen on its convex girdle, rotates smoothly and with celerity through 180° of arc, so bringing itself right side up for crawling purposes. Above all, the wonderful phenomena of *Bacillaria paradoxa* are to be explained, not by the action of an unfolding film of coleoderm, which is a practically impossible thought, but altogether satisfactorily by simultaneous currents rotating in the same direction in adjacent cells, and by consequence in opposite directions in keels in mutual contact. But the rifted keel structure of the *Bacillaria* frustule is as the structure in *Nitzschia* generally; and broadly the same may be said of *Surirella*, where independently these rotating currents are made evident by particles sticking to the coleoderm in the rift of the keel and traveling along it.

With all due deference, I would point out that it has been my privilege to demonstrate* an actual protrusion of plasma through the raphes at the corners of the frustule of *Eunotia major*. The substance issuing at these points is continuous with the internal protoplasm, stains like it with eosin, and lies between pads of coleoderm that refuse the eosin while accepting Bismark brown. To my mind it is plain enough, not only that these processes are true protoplasm, but also that they function in the orienting of the frustule by rotating it through 180° of arc, as well as in locomotion. The pads of coleoderm protect the protoplasm, no doubt, and the space between them, just as in *Pinnularia*, is in life invisibly filled with a more fluid jelly in immediate contact with, and deeply covering, this same protoplasm. All this, except the very thin jelly, keeps its place very well on staining, differing in this way from the apparently parallel arrangement in *Pinnularia*, where the coleoderm masses are less consistent, and collapse entirely when stained. Here, let it be well noted, is an instance of external protoplasm between masses of coleoderm, *all alike invisible when in operation*. Moreover, the situation of these masses in *Eunotia* is far more favorable for observation than the situation of a raphe stream of protoplasm in *Pinnularia*.

And lastly, I would mention again the very important work of L. Schütt, already cited, wherein it is shown that "plasma" exists and operates outside the silica, especially in the "centrifugal thickening" of the silicious membrane, and that "plasma" can be distinguished in that position from coleoderm (gallerte).

These are some of the reasons for saying that Lauterborn has not necessarily said the last word. For myself, while holding no brief for the existence of external plasma streams in general, I have the temerity to think him unsuccessful in his endeavor to formulate a doctrine that will fit with all the known facts. *I must think that the living substance of the cell*,

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*Errant Frustules of Eunotia major. Proc. Acad. Nat. Sci. Phila. 1898.

more or less deeply overlaid with coleoderm substance of varying consistency, and itself assuming that degree of fluidity which best meets the requirements of the situation, permeates the raphes, circulates in the keels, or in some cases protrudes quite beyond the silica, and functions as the actual propulsive agent.

This statement of the matter, though perhaps somewhat general in form, is not the result of mere cogitation. It is the carefully pondered outcome of several years' study of the phenomena of diatom motion, a study that has not seemed to me to be altogether superficial in character. I know of no fact inconsistent with this concept, and in this I include the actual facts brought to light by Lauterborn himself. It is encouraging to find, also, that the statement expresses approximately the views of Max Schultze.

The elucidation of the details of mechanism, as these present themselves in the many types of the *Bacillariaceæ*, would prove in the end an uncompleted task of a long lifetime.

CONCERNING *POTTSIELLA ERECTA*.

As interesting items in the history of this polyp, we reprint the following from the Proceedings of the Academy of Natural Sciences, Philadelphia, with subjoined notes from Mr. Edward Potts: —

August 5th, 1884. Mr. Edward Potts in the chair.

On *Paludicella erecta*. — Mr. Edward Potts desired to have a preliminary record made of his recent discovery or identification of a new species of *Paludicella*, for which he proposes the name *Paludicella erecta*.

This genus of fresh-water polyps has heretofore contained only the single clearly defined species *P. Ehrenbergi*, Van Beneden (*Alcyonella articulata*, Ehrenberg), the other two names, *P. procumbens* and *P. elongata*, suggested by Mr. Albany Hancock and Prof. Leidy, being considered by Prof. Allman as identical with the original type. The present form is strikingly different from the old one, both in the number of its ciliated tentacles and in the character of the cœnœcial cells. The doubt which has lingered in the mind of the speaker has not been as to the species, but whether, in view of the difficult determination of the characteristic septæ between the cells, amounting in fact to an apparent absence of them, a new genus might not be required to accommodate it.

It was first noticed in Tacony Creek, a small stream in Montgomery County, Pennsylvania, at that place perhaps fifty feet above tide-water. A few days after it was also gathered within tidal limits in both the Delaware and Schuylkill Rivers, near Philadelphia. In the first-named locality it was found most abundantly in the pools amongst the rapids of the stream, frequently covering the upper surface of stones, at the depth of a foot or more, to the extent of many square inches. The erect portions of the cœnœcial cells in the denser parts of the colonies are about a line in height and, standing very closely, suggest a comparison with the surface of a chestnut-burr. In the rivers they were found penetrating the mass of encrusting sponges, particularly *Meyenia Leidyi*.

These upright tubules are chitonous prolongations of very irregularly inflated cells, resting in compact disorder upon the supporting surface, crossed and connected in some manner not yet intelligible, by meandering cylindrical rhizomes, sometimes of great relative length. These are mostly terminal and simple, but are sometimes branched and frequently originate in an indifferent lateral portion of a cell. The tubular prolongations are, of course, always single; the invaginated polyp retiring within the inflated portion of the cell. Septæ were, in a few instances, discovered in the rhizomes near their insertion or connection with the inflated portion of the cells. The upright portions of those cells which seemed to be least matured were longer than those of their older neighbors, subclavate or spindle-shaped and rounded at the extremities. The others are cylindrical or slightly widening downwards and shorter than the former by the invagination of the terminal portion of the ectocyst. This has the effect of producing the angular appearance of the orifice, so familiar in the older species; but while that is generally quadrangular, this has frequently five or more sides. The younger cells are nearly transparent, but they darken with age and become somewhat encrusted with adherent particles and overgrown by commensal parasites, *Limnias*, *Pyxicola*, and the like.

The polypides are shy, but fond of the light, and when otherwise undisturbed will remain for a long time protruded in the full glare of microscopic illumination. It can then be seen that the lophophore is circular, without epistome, supporting ordinarily twenty tentacles, taking the shape of a claret glass and opening upwards. (Nineteen and twenty-one tentacles have been doubtfully counted, while the above-mentioned number is frequent; *P. Ehrenbergi* is universally stated to have but sixteen). A peculiarity of the tentacles is the presence upon the outer median line of each, of a rather sparsely filled series of quiescent setæ, in strong contrast with the rapidly moving cilia around them.

The development of this polyp from the ovum, of which interesting hints have been obtained, and its internal structural peculiarities, are reserved for further study, and if satisfactory results shall have been attained, they will be treated of in a later paper. The nearly simultaneous observation of this species in three distinct localities, and its abundance in each, indicates that it is probably not uncommon, and excites surprise that it does not appear to have been previously noticed.

Mr. Potts now adds the following: —

As the above-named *Paludicella erecta* does not appear in the work of Dr. Allman, or of any other writer upon the Fresh-water Bryozoa, it may be worth while to explain that when specimens of this form were sent, amongst other American species, to Professor Karl Kraepelin, of Hamburg, Germany, in response to his request, he determined after careful examination of the living material that "this species shows characters differing so widely from those of *Paludicella* that it cannot be permitted to remain in that genus," nor in any other as yet described. He therefore proposed "a new genus, under the name *Pottsiella*, in honor of its discoverer." He alludes in his beautiful monograph upon the "German Fresh-water Bryozoa," as does the above extract, to the substitution of hybernaculæ as methods of conservation and reproduction, in place of the familiar statoblasts of most other Bryozoans. The summer ovæ, referred to above, were again seen some years later, and figures representing them may be seen, Nos. 4 and 5, on Plate No. 4, in PROCEEDINGS OF THE DELAWARE COUNTY INSTITUTE OF SCIENCE, Vol. III, No. 3.

INTELLECT IN LOWER ANIMALS.*

BY SANFORD OMENSETTER.

The subject of intellect in lower animals is a matter too broad to be comprehensively treated in such a paper as might here be presented. That brutes to a certain extent do reason, that the limit of their mental processes is largely a question of environment, and that their brain power may be improved under patient training, are propositions the truth of which is readily admitted by the observant. The only perceptible difference between the reasoning power of men and animals is, that the latter is applied usually to the limited idea of providing for their bodily wants, whereas that of men is put to a vast amount of uses. We may cite a number of instances to prove that in the lower orders the principle of intellectuality is present in larger degree than we might suppose.

Probably no animal has been of greater service to mankind than the horse. While not so intelligent as any of the larger flesh eaters, his sagacity, if we except the elephant, seems greater than that of any ruminant, or other herbivorous quadruped. The steeds of Arabia are justly celebrated for their beauty, while their devotion to their masters has been the theme of many a song and story. No instance of greater loyalty, however, than the following from the pen of Professor Claypole, of Antioch College, Ohio, can be shown: "A friend of mine is employed on a farm near Toronto, Canada, where a horse belonging to the wife of the farmer is never required to work, but is allowed to live the life of a gentleman for the following reason. Some years ago the lady above mentioned fell from a plank bridge into a stream where the water was deep. The horse, which was feeding in a field close by, ran to the spot and held her up by his teeth until assistance arrived, thus probably saving her life."

Concerning a less desirable trait in that much maligned servant, the mule, Professor Nipher, of Washington University, St. Louis, says: "A friend of mine living at Iowa City had a mule, whose ingenuity in getting into mischief was more than ordinarily remarkable. This animal had a great liking for the company of an oat bin, and lost no opportunity, when the yard gate and barn door were open, to secure a mouthful of oats. Finally the mule was found in the barn in the morning, and for a long time it was found impossible to discover how he had come there. This went on for some time, until the animal was caught in the act. It was found that he had learned how to open the gate, reaching over the fence to lift the latch, and then he effectually mystified his masters by turning round and backing against it until it was latched. He then proceeded to the barn door, and pulling out the pin which held the door, it swung open of its own accord. From the intelligence which this animal displayed on many occasions, I am of the opinion that had not discovery of his trick prevented, it would soon have occurred to him to retrace his steps before daylight, in order to avoid the clubbing which the stable boys gave him in the morning. It may be added that this animal had enjoyed no unusual educational advantages, and his owners found it to their interest to discourage his intellectual efforts as much as possible."

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* Paper read before the Institute.

With regard to the general intelligence of those animals which chew the cud, this illustration, taken from Thompson's "Passions of Animals," shows the tactics employed by the vast herds of buffaloes which roamed the interior basin: — "The sagacity with which the bisons defend themselves against the attack of wolves is admirable. When they scent the approach of a drove of these ravenous creatures, the herd throws itself into the form of a circle, having the weakest and the calves in the middle, and the strongest ranged on the outside; thus presenting an impenetrable front of horns."

The otter is an animal now almost extinct in Delaware County. The fact of their being taught to catch fish and bring them to their masters, shows no small degree of docility on their part. "I have seen," says Dr. Goldsmith, "an otter go to a gentleman's pond at word of command, drive the fish into a corner, and, seizing upon the largest of the whole, bring it off in his mouth to his master."

The sphex wasp is a burrowing insect which provides food for its young by paralyzing the nerve centres of its prey by stinging. A similar occurrence has been noted by a writer in the "Magazine of Natural History," who relates: — "I dug out five young polecats, comfortably embedded in dry, withered grass; and in a side hole, of proper dimensions for such a larder, I picked out forty large frogs and two toads, all alive, but merely capable of sprawling a little. On examination I found that the whole number, toads and all, had been purposely and dextrously bitten through the brain."

All are acquainted with the extraordinary wariness of rats in regard to traps, which is only equalled in the animal kingdom by that of the fox and the wolverine. It has frequently been regarded as a wonderful display of intelligence on the part of rats that while gnawing through the woodwork of a ship, they always stop before they completely perforate the side, but this is probably due to their distaste of salt water. No such disparaging explanation, however, is possible in some other instances of the display of rat intelligence. Thus, the manner in which they transport eggs to their burrows has been too frequently observed to admit of doubt. "The captain of a merchantman trading to the port of Boston had constantly missed eggs from his sea stock. He suspected that he was robbed by his crew, but not being able to discover the thief he was determined to watch his storeroom. Accordingly, having laid in a fresh stock of eggs, he seated himself at night in a situation that commanded a view of his eggs. To his great astonishment he saw a number of rats approach; they formed a line from his egg basket to their hole, and handed the eggs from one to another in their forepaws."

The higher mental faculties of the elephant are more advanced in their development than in any other animal except the dog and monkey. The general fact that elephants are habitually employed in certain parts of India for the purposes of building, storing lumber, etc., in itself shows a level of docile intelligence which only that of the dog can rival. Speaking of the labor of piling timber, Sir E. Tennent says that the elephant "manifests an intelligence and dexterity that are surprising to a stranger, because the sameness of the operation enables the animal to go on for hours disposing of log after log, almost without a hint or direction from his attendant. For example, two elephants employed in piling ebony and satinwood in the yards attached to the commissariat stores at Colombo were so accustomed to their work that they were able to accomplish it with equal precision and with greater rapidity than if it had been done by dock laborers. When the pile attained a certain height and they were no longer able by their conjoint efforts to raise one of the heavy logs of ebony to the summit, they had been taught to lean two pieces against the heap, up the inclined plane of which they gently rolled the remaining logs, and placed them trimly on the top." Dr. Erasmus Darwin records an observation which was communicated to him by a "gentleman of undoubted veracity" of an elephant in India which the keeper was in the habit of leaving to play the part of nurse to his child when he and his wife had occasion to go away from home. The elephant was chained, and whenever the child in its creeping about came to the end of the elephant's tether, he used gently to draw it back again with his trunk.

An instance of the high reasoning power of the cat has been thus related: "While a kerosene lamp was being filled, some of the oil fell upon the back of the cat and was afterwards ignited by a cinder falling upon it from the fire. The cat with her back in a blaze in an instant made for the door (which happened to be open) and sped up the street about a hundred yards, where she plunged into the village watering trough and extinguished the flame. The trough had eight or nine inches of water, and puss was in the habit of seeing the fire put out with water every night." The latter point is important, as it shows the data of observation from which the animal reasoned.

The sagacity of the fox is proverbial. Numberless incidents are on record showing the remarkable cunning of this animal in procuring bait from traps without allowing himself to be caught. A correspondent of *Nature* says: "Some years since, while hunting in northern Michigan, I tried with the aid of a professional trapper to entrap a fox which made nightly visits to a spot where the entrails of a deer had been thrown. Although we tried every expedient that suggested itself to us we were unsuccessful, and, what seemed very singular, we always found the trap sprung. My companion insisted that the animal dug beneath it, and putting his paw beneath the jaw, pushed down the pan with safety to himself; but though the appearance seemed to confirm it, I could hardly credit his explanation. This year, in another locality of the same region, an old and experienced trapper assured me of its correctness, and said in confirmation that he had several times caught them, after they had made two or three unsuccessful attempts to spring the trap, by the simple expedient of setting it upside down, when of course the act of undermining and touching the pan would bring the paw within the grasp of the jaws."

Nor is the fox's congener, the wolf, less strategic. The following came under the notice of the Secretary to the Government of the Northwest Province: He saw two wolves standing together, and shortly after noticing them was surprised to see one of them lie down in a ditch, and the other walk away over the open plain. He watched the latter, which deliberately went to the far side of a herd of antelope standing in the plain, and drove them, as a sheep dog would a flock of sheep, to the very spot where his companion lay in ambush. As the antelope crossed the ditch, the concealed wolf jumped up, seized a doe, and was joined by his colleague.

The emotional life of the dog is highly developed — more highly, indeed, than that of any other animal. In this connection we may point out the remarkable change which has been produced in the domestic dog as compared with wild dogs, with reference to the endurance of pain. A wolf or a fox will sustain the severest kinds of physical suffering without giving utterance to a sound, while a dog will yelp when any one accidentally treads upon his toes. This contrast is strikingly analogous to that which obtains between savage and civilized man. The North American Indian, and even the Hindoo, will endure without a moan an amount of physical pain — or at least bodily injury — which would produce vehement expressions of suffering from a European. And doubtless the explanation is in both cases the same — namely, that refinement of life engenders refinement of nervous organization.

The sense of justice in the dog is highly developed. If a master is not equal in his ways toward his dogs, the dogs are very apt to discover the injustice and to resent it accordingly. In this connection the well-known observation of the great Arago may be taken as being typical. Having been detained by a storm at a country inn, and having ordered a chicken for his dinner, Arago was warming himself by the kitchen fire, when he saw the innkeeper put the fowl on the spit and attempt to seize a turnspit dog lying in the kitchen. The brute, however, refused to enter the wheel, got under a table, and showed fight. On Arago's asking what could be the meaning of such conduct, the host replied that the dog had some excuse, that it was not his turn, but his comrade's, who did not happen to be in the kitchen. Accordingly, the other turnspit was sent for and he entered the spit very willingly, and turned away. When the fowl was half roasted, Arago took him out, and the other dog, no longer smarting under the sense of injustice, now took his turn without any opposition, and completed the roasting of the fowl.

Lord Truro, touching upon the craftiness of dogs, narrates the story of a dog that used to worry sheep at night. The animal quietly submitted to being tied in the evening, but when everybody was asleep he used to slip his collar, worry the sheep, and, returning before dawn, again get into his collar to avoid suspicion. The method of procedure, noted by two English observers, has been corroborated by Delaware County farmers : — "And here let me ask if you are aware of the cunning and sagacity of these sheep-killing dogs, that they never kill sheep on the farm to which they belong, or in the immediate vicinity, but often go miles away ; that they always return before daylight, and before doing so wash themselves in some stream to get rid of the blood ?"

As an example of the reasoning of Esquimaux dogs in the presence of possible danger, Darwin, in his "Descent of Man," quotes Dr. Hayes, who in his work on "The Open Polar Sea," repeatedly remarks that his dogs, instead of continuing to draw the sledges in a compact body, diverged and separated when they came to thin ice, so that their weight might be more evenly and widely distributed. This was often the first warning which the travelers received that the ice was becoming thin and dangerous. Mr. Darwin observes, "This instinct may possibly have arisen since the time long ago, when dogs were first employed by the natives in drawing their sledges ; or the Arctic wolves, the parent stock of the Esquimaux dog, may have acquired an instinct impelling them not to attack their prey in a close pack when on thin ice."

Nor are the mental attainments of some of the feathered tribe to be passed with diffidence. Probably our most acute species is the common crow. "The wariness and distrust which the crow evinces are strangers to its nature and have only been developed by the long and bitter persecution to which it has been subjected. In some localities the happiness of its existence is considerably marred by the extreme and constant vigilance which has to be kept up in view of the dangers to which it is exposed, and by the new mental attainments which have to be acquired in order to adapt the conditions of life to environing circumstances. In regard to the caution of the crow, we should not allow an interesting fact to escape attention. If the cause of the alarm should be two men, whether armed or not, the disappearance of one man after a flock has taken flight is at once recognized by the monitors, and nothing will induce them to signal the return of their comrades, however artfully concealed the remaining man may be. But let the latter depart, the intelligence is immediately communicated, and the flock silently appears and renews operations.

It is evident from the foregoing that the crow possesses some knowledge of numbers. Professor Thomas G. Gentry had it from a reliable source that its knowledge of counting is very limited and does not extend beyond the number five. The information was determined in this wise: A tent was erected in the middle of a corn field daily visited by these birds. At first a couple of men entered it, thus frightening the crows away. After the lapse of a half hour one of the men retired, thinking thereby to deceive the crows. An hour passed and none made an appearance. The second man then left, and after having vanished from view, the birds settled down in immense numbers. At this moment a trio of men appeared and entered the tent. Shortly afterwards, one left; then another, the third remaining closely hid from view. But it was not until after the third man had departed that the crows returned. Four men next entered, and subsequently five, with like results. Finally, a party of six men went into the enclosure, and all left excepting one. After the fifth man had disappeared the crows began to settle down upon the field in great numbers, evidently unconscious of any hidden danger, when to their utter dismay and confusion the sixth man appeared. From the preceding there seems to be but one conclusion that can be rationally drawn, that five expresses the extreme limit of the crow's idea of numbers.

In "Unbeaten Tracks in Japan," this observation on the crows of that country is made: "In the inn garden I saw a dog eating in the presence of several of these covetous birds.

They evidently said a great deal to each other on the subject, and now and then one or two of them tried to pull the meat away from him, which he resented. At last a big, strong crow succeeded in tearing off a piece, with which he returned to the pine where the others were congregated, and after much earnest speech they all surrounded the dog and the leading bird dextrously dropped the small piece of meat within reach of his mouth, when he immediately snapped at it, letting go the big piece unwisely for a second, on which two of the crows flew away with it to the pine, and with much fluttering and hilarity they all ate, or rather gorged it, the deceived dog looking vacant and bewildered for a moment, after which he sat under the tree and barked at them inanely. A gentleman told me that he saw a dog holding a piece of meat in like manner in the presence of three crows, which also vainly tried to tear it from him, and after a consultation they separated, two going as near as they dared to the meat, while the third gave the tail a bite sharp enough to make the dog turn round with a squeak, on which the other villains seized the meat, and the three fed triumphantly upon it on the top of a wall."

INDIAN REMAINS IN DELAWARE COUNTY.

One of the most interesting lines of local historical research is that concerning the one time Indian inhabitants of the County. From time to time many Indian "relics" have been picked up in the country districts and there is scarcely a farm house which does not count among its curios a collection of Indian arrow-heads. Unfortunately, however, these specimens have been passed back and forth from one local collector to another until accurate knowledge of the location of the original finding is lost. When, therefore, a collection of relics is found of which there is no question as to the locality, it is a matter of scientific interest to make a careful record thereof.

One such authentic collection was made by T. Chalkley Palmer, President of the Institute, on the bank of the Delaware River in the City of Chester, near the foot of Broomall Street, the locality occupied by the works of the American Dyewood Company. This collection was described in Volume I, Number 2, of the PROCEEDINGS, and the specimens are now in the museum of the Institute.

Another authentic collection is one made by Benjamin T. Levis, of Media, the relics having been found on the property of Nathan L. Pratt, in Marple Township. There is no doubt regarding the exact locality of the finds, and the large number of relics brought to light year after year indicates an Indian camp or village in this neighborhood. The tract upon which the relics were found comprises some twenty acres of bottom land lying on the northeast side of Crum Creek, about a quarter of a mile above the old Palmer's mills. There are several springs on the property, one of which has been for many years known locally as the "Indian Spring." The relics in Mr. Levis' collection comprise the following: Broken pottery, stone darts and spear heads, stone axes, stone knife, grinding stone or mortar, jasper chips, etc. These finds were picked up personally by Mr. Levis, so that their location is without question.

Another locality which has been quite famous locally in connection with the Indians is the district near the Barren School House, on the road leading from Lima to Sycamore Mills. There are several traditions of Indian camps in this locality. Unfortunately, however, no record has been kept of the various specimens found in this vicinity.

Not far from this same locality, on a branch of Dismal Run, there is found what is locally known as the "Indian Rock." In Volume II, Number 3, of these PROCEEDINGS is shown a photograph of this remarkable specimen, together with what is known of its history.

Another locality reported as a favorite Indian camping ground is on the northeast bank of Crum Creek, on the Enos Williamson farm, a half mile or so above the crossing of the Newtown and Sycamore Mills road. While few collections are known from this locality, family traditions show quite conclusively that the Indians were in the habit of congregating in this neighborhood. This district and its history are fully treated of in Volume IV, Number 1, of these PROCEEDINGS, to which reference may be had.

MINUTES OF THE INSTITUTE.

FEBRUARY 3, 1910. — Regular monthly meeting, with Vice President Henry L. Broomall in the chair. Reports of Curators and committees, routine business, etc. William R. Newbold, Jr., of Panama, donated to the museum a number of articles from that region. Among these were several swords of ancient pattern, a machete, beads, etc. A number of microscopic specimens were exhibited, comprising minute geode crystals from South Dakota, voluntary and involuntary muscle tissue, *Trichina spiralis*, etc. After discussion the meeting adjourned.

FEBRUARY 10, 1910. — Adjourned meeting. Lecture, "High Temperatures," illustrated with experiments, by Dr. C. B. Thwing.

FEBRUARY 24, 1910. — Adjourned meeting. Lecture, "America, England, and the Ocean Between," by Prof. Wilkie Nelson Collins, of the University of Pennsylvania.

MARCH 3, 1910. — Regular monthly meeting, with Vice President Henry L. Broomall in the chair. Reports of committees and routine business. Under scientific business a number of topics were discussed. Among other things attention was called to the progress made in the education of an orang utan and a chimpanzee in the possession of Dr. Henry H. Furness, of Wallingford, Delaware County, Pa. It is stated that they have advanced so far as to be able to pick up articles of a given color, thread needles, tie knots in ropes, point to the ears, eyes, mouth or nose on demand, and even attempt to pronounce the word "papa." After discussion the meeting adjourned.

MARCH 17, 1910.—Adjourned meeting. Lecture, "Saint Patrick," by Dr. E. D. Fitch.

MARCH 24, 1910.—Adjourned meeting. Lecture, "The Trend of Thought as Reflected in the Mirror of History," by Ernest Leroy Green, Esq.

APRIL 7, 1910.—Regular monthly meeting. In the absence of the president and vice president, C. Edgar Ogden was called to the chair. Reports of Curators and committees and routine business. J. Claude Bedford, of Media, Pa., was elected to membership. Nominations of officers for the ensuing year were received. C. Edgar Ogden presented some specimens collected on a recent visit to Florida, and spoke at some length upon the palmetto tree and its uses. Adjourned.

APRIL 14, 1910.—Adjourned meeting. Lecture, "The Foreign Word," by Henry L. Broomall, Esq.

APRIL 28, 1910.—Adjourned meeting. Illustrated lecture, "St. Peter and St. Paul at Rome," by Henry C. Savage.

MINUTES OF SECTION A.

February 17, 1910. — Dr. B. M. Underhill exhibited four specimens of pigs' feet with solid instead of cloven hoofs. These feet were taken from a two days old pig, one of a litter all showing the same characteristic. He also exhibited a dissected specimen of one of the hoofs. It was stated that this breed of hog was becoming quite common by artificial selection and that it was somewhat difficult to reconcile the existence of the solid hoof with the recognized laws of evolution. T. Chalkley Palmer gave an interesting talk on diatoms, and showed specimens under the microscope. C. M. Broomall called attention to the laws of reflection governing the concentration of energy in the Thwing high temperature thermometer. Adolphus Leland exhibited some microscopic quartz crystals. Adjourned.

March 10, 1910. — Illustrated lecture, "Theories and Facts Concerning Arthropodal Vision," by Albert S. Barker. Mr. Barker's remarks upon this subject are set forth in Volume V, Number 2, of these Proceedings.

March 31, 1910. — Henry L. Broomall and others gave descriptions of various optical effects at sea. C. Edgar Ogden related an interesting account of a recent trip to Florida, and presented a number of mineralogical and botanical specimens. Mention was made of a recent article describing a white rainbow. C. M. Broomall gave a short talk on the theory of wind vanes and their accompanying eddy currents. A. H. Moon mentioned a number of optical illusions and mathematical puzzles. Adjourned.

April 21, 1910. — C. M. Broomall described the methylene blue test of the bacterial stability of water and exhibited bottles showing the decolorization of the solution by the action of anærobic bacteria when the bottles were corked and the recovering of color by oxidation when the bottles were uncorked. Benjamin F. Fields presented a large specimen of yellow fungus found near the Media water works. This was identified as *Polyporus sulphureus*. Dr. Underhill gave an interesting talk on the geological history of animals, calling attention to the course of evolution through successive ages with the accompanying rise and fall of animal species. Adjourned.

Officers of the Institute:

President, - - - - T. Chalkley Palmer
First Vice President, - - Henry L. Broomall
Second Vice President, - - Charles Potts
Secretary, - - - Dr. B. M. Underhill
Treasurer, - - - - Carolus M. Broomall
Librarian, - - - Henrietta K. Broomall

Board of Curators,

Edgar T. Miller, Homer E. Hoopes and the Officers

Vol. V, No. 4 July, 1910

PROCEEDINGS

OF THE

DELAWARE COUNTY INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:
T. Chalkley Palmer, Chairman; Henry L. Broomall,
Trimble Pratt, M. D., Charles Potts,
B. M. Underhill, V. M. D.

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. V, NO. 4 JULY, 1910

WASTED ENERGY IN ART EDUCATION.

BY ALBERT W. BARKER.

While almost all schools and many universities offer what is called art instruction, it does not follow that this represents agreement in aim among the school-boards, trustees, committees and teachers who have charged themselves with the work, nor that a substantially coherent and adequate result has followed upon it. Everything that has been made by the hands to give pleasure or instruction to the eye is brought before some class or other as a product of art, to be done over or praised or imitated, and this is called an art lesson. The field of nature has been searched for objects to draw or model or arrange, and the most diverse ideas are gravely proposed concerning their relation to art and this also is an art lesson. Before the work of art, the philosophizer has dealt in abstractions and generalizations, and as in modern tales of crime and detection, has found every motive and traced every step, showing how easy all is with once the clue in hand. Lastly, the mere chat and gossip of the studio has been carefully set down as though of precious benefit to the student, and this in detail, sifted and expanded, has been an art lesson. Meantime, down to the very fundamentals of purpose and method, art instruction means entirely different things in different schools.

In so far as this represents natural and reasonable difference of viewpoint, and a healthy state of ferment it is well, but in fact it also shows that we are yet far from a definite general conviction as to what we are about. In order to get the most good out of art education we must reach some sort of agreement as to what good we are to expect and some general agreement as to how to get at it. To hope, for instance, to get culture out of the essentially disciplinary work of drawing is bad enough, but to use time needed for discipline on what might be cultural if the pupil were prepared, or worst of all to spend that time on what is at best no more than rather poor play, is to risk the future of a valuable element in public school work. Though it be recognized that art education is an effort toward something needed, and greatly needed, it will nevertheless be displaced from these schools unless we get discipline from exercises for discipline and develop appreciation so far as we can, from work professedly cultural. The instinct that has brought this work into the schools is strong and good ; we are only beginning to know what it means. We must find out what it means, and get the good of it, or an instinct equally strong and good will remove the useless subject.

Of the disciplinary work in art education, freehand drawing is the type. The value claimed for it as a part of fundamental education lies in the fact that it develops, more surely than any other means, the habit of looking intently at things, and that eyes so habituated report with increased accuracy. It is through the senses that the brain gets its premises, and the logical mind is of small use without just premises on which to build. Words are but the abstracts of facts, and at second hand, and must be continually checked by the observant people of the time. It is in making observant people out of the unobservant, and in helping the observant to greater accuracy, that the teacher of drawing finds the best reason for his work in the elementary schools. The ability to draw well enough for all ordinary purposes should come with this, and is of continual use. Many things that we see can be recorded and compared only in drawings or the like, so that even the untrained try to explain themselves by sketches or diagrams, knowing practically that for some things the poorest sketch is better than the best of words. Drawings, models, and constructions of all sorts, including sculpture and architecture, appeal directly to the eye in this way, but as all of the latter, except perhaps the slightest of clay sketches, are projected or visualized as drawings before they are made, it is clear that drawing of some kind, whether with brush, pencil or pen, is the language of unrivaled usefulness in the communication of those impressions and ideas that reach us through the eyes. The drawings that we make are the test and expression of the accuracy of our observation, just as our words measure us to the ideas that may be expressed in words. Nor is drawing anything more than a language. In itself it is not an art, but the means of an art; a language that may be the medium of an art as the spoken language may, but, like it also, may be used for a simple record of fact.

To develop the observing power and to learn to draw well enough for ordinary purposes is as easy as to learn to read. To develop an art-sense is much more difficult and less certain. Poets are born, and the poetic sense is hardly to be made by rule. One thing, at least, is sure, that no one can hope to design beautiful things nor even appreciate the character of such who cannot draw or copy a shape when it is set before him. How could one hope to choose or arrange forms whose fundamental properties are lost on him? We cannot become an artistic race by an act of will. Even bettered observation will not alone accomplish it. It is by exposure to definite impressions that we may hope to become discriminating, to see that some shapes and lines express vigor, grace, directness, dignity, or on the other hand weakness, frivolity, vanity, falsity, confusion. However, we must be exposed to definite impressions and be of patience in waiting for a reaction. Much as we may wish to make our children sensitive to the expressive character of shape at one step, it must necessarily be by many steps while the eyes are being opened. Then, if at last we do not need to be told that some vase embodies the Greek clarity of thought and the Greek restraint, but the sight of the vase carries the conviction more directly than words, then perhaps when we build our houses and furniture, and make our pictures and jewels, it may be that these works will take their shape from the actual motives of our lives, and not be an inexpressive compound of misunderstood borrowing and blundering invention. Our tools, our things of use, are up to the present time much more intelligible than our art, and much more sincere. Thus it is that while the direct benefits of the disciplinary work of art education are bettered observation and a useful familiarity with the language of the pencil, the disciplinary exercise is also the necessary preliminary to cultural study and the evolution of latent creative impulses. To recognize that the subject as taught in the public schools should be restricted to those methods and elements that are of immediate and universal value, is to ensure its value as a preparation for professional education also.

Of the published systems of art education now in general use, there is not one that does not afford a sufficient variety of lessons that are entirely suited to this purpose, but unfortunately there is not one in which all the lessons are good or even harmless, as generally given in practice. The question of the value of such a system, or of any possible system, must of course depend on its interpretation—on what to lay stress and spend time, over what to pass lightly. Since it is often in the hands of teachers without enough special training to give them confidence in their own judgment as against the authority of the system, this interpretation is often quite literal and tempered only by convenience. Yet the test would be easy enough.

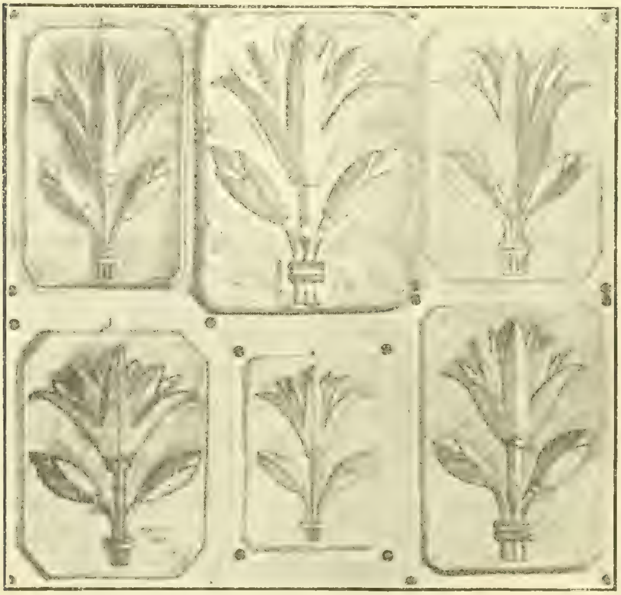
To set definite standards before the child and hold him to definite statements is our clear duty. To set before him objects of obvious shape or color and to require a reasonable degree of accuracy in stating these fundamental properties of height and width and direction of shapes, and the depth or intensity of color are much more work for teacher and pupil than "playing at artist," but it is good, wholesome work, with good results to show for it, and not a kind of play less healthful than games out of doors.

Our concurrent duty is to see that these objects and standards are good as well as distinct. Fortunately this basis for the development of good sense in design is as easy as it is necessary. The ordinary useful utensils and tools, cups, pitchers, baskets, are good and distinct just in proportion as they are ordinary and useful, and just in proportion as no conscious idea of design went into their making. They are expressive in a high degree because their purpose is expressed in the simplest and frankest way in a suitable material used with strict regard to economy with strength.

Among natural forms, those that are especially characteristic, those that we say have shape, rather than those that we call shapeless, are to be preferred. It is easier for a child to make a drawing that might be like some potato than to make a drawing that might be like some turnip, because "turnip-shaped" means something, and for that reason, to draw the turnip is an exercise that is worth the time. Our common speech gives us sufficient hints, we say pear-shaped, turnip-shaped, and so forth, but we do not say potato-shaped, for that means too many things, and is too vague to be useful as a definition. To make a drawing like a particular potato would be a problem too difficult for the average child by reason of that vagueness of form.

When it comes to a question of conscious design and of ornament, we must remember our weakness and be wary. We may, however, confidently lay stress on the exact observation of the simpler examples of the great periods, as the way toward the understanding of visualized expression at its highest point. The Greeks have left us admirably simple designs which are perhaps the only ornament which all are ready to accept as, humanly speaking, perfect in its place. In geometric ornament, the Saracens, who would imitate no living form, made what is recognized as the highest achievement. As nature in her economy of means makes her beauty out of the most necessary functional parts, as the leaves and flowers of plants, the shells of molluscs and so forth, so the craftsmen of the great Gothic period gave us beautiful structural forms which blossom into ornament, and these are our standard of artistic integrity. To study historic ornament is to study these highest works for their special lessons, but even more for the inspiration of high success. For the child to draw some of the simpler examples is justifiable merely as a part of history, the history of the things men have made with scrupulous care, and of all they have made, have thought best worth preserving. As enriching the mind with a basis for evolution, *what has been done and how it was done*, far exceeds in interest and value the placing of abstract units according to abstract rules. Theories of design, of balance, rhythm, harmony and so forth, are of very dubious value. These qualities exist in the greatest art, but also in the poorest, and it still matters more what we balance and how, what we repeat and how, and what we harmonize, and about what principle. Hitherto works of art have always come when, in the satisfaction of common needs, a people has found a suitable medium and has satisfied the need so well that the result became expressive in a pleasurable degree. The perfect work of art therefore would include the perfect performance of some function in the terms of a medium, language or material absolutely appropriate and used with full regard to its genius or character. Such a work would have the emphasis, the style, the integrity which are the qualities by which we recognize the work of art. It will be harmonious from within out, and balanced, because all its parts are in due proportion, with neither scantiness nor excess, and sometimes, but not always, it will be rhythmic, for functional reasons, as in the arches of a bridge and in repeating ornament, or in order to stimulate or charm to better service the communicating nerves. Such a work has never been made from a formula, nor with the wish to be artistic leading us backward from effect to cause. The great Renaissance is proof of this, in that its product falls appreciably short of that of the preceding Gothic period in sincerity and force, except where, as in realistic painting and sculpture it was really in no sense a rebirth or attempt to revive old ideas. In these it was a spontaneous impulse, inspired indeed by a sense of the greatness of the ancient examples, but doing quite another thing according to laws and within limits which were then to be discovered. To let the study of historic ornament go hand in hand with elementary work in design for construction, in association with "manual training" and with the arrangement of natural and geometric forms for ornament, is easy enough. It is perhaps going too far for public school work, the purpose of which is not to prepare children to be craftsmen or designers, but to give only that which is certain to be of value to all. If it is to be done at all it must be done with the principle clearly in view that design begins with the constructive basis, and that to enrich a bad form or to add ornament which is not coherent with the form is an unmitigated evil. If on the one hand the public school must not be expected to do the work of the vocational school, it may justly be required to do nothing that the vocational school will have to undo. This is a point at which it may be tested fairly. Leaving to the decision of time the points about which battle is being raged, there are several things that are done in the public schools that are not tolerable from any professional viewpoint. A child should not be required to do work for which neither he nor the teacher has any standard, such as mussy landscapes in water color, or illustrations of events in distant history. Neither should a child, because he cannot draw well, be shown ill-drawn figures as models, and then be called upon to draw similar figures from memory. Such a demand is outrageous if it means anything. As a matter of fact it means nothing. Even were the models well drawn, not one child in a hundred is prepared to get benefit out of such work, and not one teacher in a hundred is prepared to offer just criticism. It would be interesting, but might lay grounds for libel, to publish in this connection fac simile reproductions of illustrations from the better known systems of art education. That with bad drawings given as drawing models, bad perspective in the perspective lessons, and crude ugliness shown as beauty there are mingled exercises that could not be bettered, is true, but the evident value of these leads the teacher and pupil alike to suppose that some virtue must exist in the others, and encourages the dangerous delusion that art and art education are in some way different from other education, and confer mysterious benefits in mysterious ways. Moreover, this mysterious benefit must approach the miraculous in the mind of the child who is taught that by dropping primitive colors together haphazard on wet paper and then letting them blend by accident he is getting a thing of beauty. Surely this is not fair to the child. Neither is it fair to the child to teach him that by folding a piece of paper over a blot of ink and opening it up again that he has an expressive decorative unit or a thing of beauty. It is not fair to the child to have him paint a patch of blue blending into a patch of green and to tell him it looks like a spring landscape. It may or may not, but it is sheer accident if it does. It is not fair to a child to show him an apple and tell him to draw it with a blunt red crayon, and then to tell him that a scratchy red patch is "very good." It is not fair to a child to let him draw from a flower on his desk, lying this way and that, and then to take the result away with a hundred others and mark them good or bad by memory of that kind of flower, or upon neatness of execution, without reference to the flower that was before each child and in his presence. It is not fair to a child to keep him at work in all his drawing periods for two months making a portfolio to keep drawings safe when he might be learning to state the height and width of simple objects in ten-minute drawings. These would be valuable only for the discipline obtained, and therefore would not have to be kept safe. It is not fair to the child to use models that are too small or put them where they are partly hidden by the heads of the pupils in front of him. It is not fair to a child not to give a large percentage of the available time to drawing for correct proportions. It is hard work for the teacher, but teachers have to work hard. It is not fair not to show the child his errors in time to give opportunity to correct them: in the study of drawing, results are always approached by trial and correction. It is not fair to the child to teach him or permit him to depend on pencil-in-hand measurements or ruled lines. The straight lines and measurable dimensions are easy. The hard problems must be solved by the hand and eye unaided, and they become capable of these through the doing of the easier. It is not fair to the child, nor to the children of the next generation to let the subject degenerate into kindergarten play. Because it has led to no adequate result in incompetent hands, certain school-boards have displaced drawing altogether or in part for instrumental draughting, which is a useful craft, but which has none of the character-building power that exists in freehand drawing when properly taught. It may be answered that all that can be done, is done: that children are incapable of more, and that teachers have neither the time nor the energy to do the work properly. This last is true in a measure at least, but there is another side to the story. To do the really valuable part of the work and to do it right, would take no more time or energy than is now wasted.

The examination drawings made by public school students at the time they enter a vocational school of art are a fair test of the way in which the subject is taught in the public schools. If these drawings are right in the essentials, if they show that the student has been taught that the large proportions are most important, that detail is secondary, that construction and the relation of parts are of more consequence than surface markings and subtleties of form, and if we find that facility with the tool has not outstripped truth of statement, then we shall have nothing to undo. Let us look at the facts. The illustration shows a group of such drawings and the cast from which they were made. It includes the best, but not the worst, none for which the entering student was conditioned or rejected. The execution is quite ahead of



the draughtsmanship. The natural sense of proportion of these students was not at fault, but their training, for under question they answered with almost invariable correctness as to their own errors. That this result is not the fault of the student is further shown by the fact that these same students were in three or four weeks drawing in good general proportion, were members in good standing of a strong class.

In passing to the work of a vocational school the student is apt to find that little regard is paid to the work he has done in the public schools, whether it be much or little, or of what sort. He must start afresh. From this point forward the waste of energy is greatly reduced, in so far as it is caused by the futility of the work as planned. At the worst the exercises are insufficient or badly related rather than bad in themselves. If they do not make scholarly artists, architects and craftsmen, it is either because teacher or student is not capable or that the work laid out is not alone sufficient to constitute an education in art.

Failure on the part of the student is sometimes due to real incapacity on his part or that of his teachers, but the tragedy of the man who grows to middle life on the dreams of genius without the power to realize them, and is forced at last to do any work that he can get, is so common in the world of art as to call for some other explanation. These lamentable failures are not due, as a rule, to general constitutional incapacity, for such students are usually intelligent and industrious. It is because they have determined to do just that work which depends absolutely on rare personal gifts and disregarding the probabilities, they have not been constrained to work toward the ambitious end by the way of reasonable and useful apprenticeship. If a boy displays an aptitude for the use of language, a wise parent or a wisely conducted school considers it a gift that may be turned to his account in his future. He may be able to use that gift as a teacher, a journalist, or a pleader. Neither the school nor the father has any right to build on the possibility that the boy may be the great poet or novelist of the next generation. It may be, and it will come if it must, but as the foundation for a useful future the basis is too doubtful. But if a boy shows a talent for drawing, the first thought is to make a painter of him, a poet of tones and colors. A whole history of disappointments and wasted lives is based on the one fact of real talent unapplied, of talent unequal to genius, and never trained to any particular purpose. Nor is there anything but gain for the student who passes to independent creative work through craftsmanship. The greatest painters of the Renaissance were trained in the shop of the craftsmen; they were apprenticed and learned their trade.

Lastly, the question may be raised as to whether the schools for the training of professional workers offer to their students a reasonably complete and sufficient system of education in that which they profess to teach.

These schools may be divided into two classes. One of these classes includes the schools of architecture that exist in universities and schools of technology, and the schools of industrial and applied art. The schools of architecture of the better class enjoy a high reputation, as preparing their students to enter the offices of the practising architect with enough knowledge to make them useful at the start and to enable them to develop in contact with actual problems encountered. The graduate of a school of this sort has been taught draughtsmanship and design, the methods of construction employed by the mason, the carpenter and the ironworker, the means of heating buildings, and has been instructed as to ventilation, plumbing, drainage, and so forth. He has been especially trained as to how men in other times and places have met their particular problems with the available materials, and how styles have developed thereby. Meanwhile his teachers have shown him how to use his instruments, his pencil, pen and ink, charcoal and water-color with regard to the possibilities of each. At certain times he has been working in the chemical laboratory, at others studying English and French or German, trigonometry, analytic geometry and the science of perspective, and is required besides to attend various special lectures. In all this the architectural schools are greatly assisted by the general recognition of subsequent office work as a necessary part of an architectural education, and by the fact that works of this art must stand the test of the weather. The only serious division among architects as to the present methods arises from differences of judgment as to the value of formulations of architectural fitness and beauty. Although this is a diversity of opinion over a vital matter and although the waste of energy is probably considerable at this point, it is not, strictly, so chargeable. Every generation must formulate its belief, and the next must attack or defend that formulation; the resulting loss is the unavoidable cost of progress. In any case it does not affect the general efficiency of a system, which while teaching the technic of the draughtsman and developing the power to design, bases the education of the student on a knowledge of architectural standards and principles, and of architectural history, and prepares him to work according to modern constructional methods, in collaboration with others, under the influence of office traditions founded in successful practice. An architect is much more apt to have developed abilities and a scholarly mind than any other artist of this period. The schools of applied art are endeavoring, with equal earnestness and success, to combine the resources and attainments of the thoughtful designer with the sensitive eye and skilful hand of the craftsman.

In the other class of schools, those that profess to train the painter and the sculptor, the time is given almost exclusively to the important disciplinary work of drawing and modeling from casts of antique sculpture and from the living figure. Whether the work is well done or ill done, depends on the school and on the student, and there is a great variety in both. There is no question as to the importance of this work, but the real question remains as to whether the power to draw and paint and model is all that the painter or sculptor needs. The successful student learns the language and is called an artist, but speech alone does not confer the power to say things worth saying, nor to say that which is suitable to a given occasion. He has been given the opportunity to learn through practise and with the help of an occasional criticism, to describe what is set before him He has been encouraged, but not required, to learn something of composition, of anatomy, of perspective (a few lectures on these subjects being given during the year), but no other requirement of scholarship has been even suggested to him. An instructor in such a school has said, "If a man wants to paint heads, I do not see what better thing he can do than to start in and paint heads, and keep on painting heads until he can do it right." But it is not fair to a student to teach him that even portraiture is merely a matter of painting a head. If a man has anything better in him than to paint head studies and life class studies all his life, if his language of the brush is to be the means of an art and not in itself an end, it would seem fair to instruct him in the art, and so help the artist in him to utterance. It is not fair to the student to train his eyes to see, and to leave his brain so untouched that he does not know the expressive values of the forms and colors that he sees, does not know their pictorial interest or value. He goes through a long and serious discipline in the making of studies, if the school is a good school, but although he is to be a painter of pictures, he gets no similar discipline in picture making. He does not hear paintings judged as pictures, but as examples of draughtsmanship and color, and he and his fellow students have seen themselves judged, not as they showed pictorial instinct or power, but as they could draw.

It is not fair to the young student, who stands in danger among the fluctuating opinions of the moment, not to steady his immature judgment by inculcating knowledge of that which has survived the equally changeful currents of the past, with what we can learn as to the reason for that survival.

It is not fair not to guard him against the influence of those whose worship of "individuality" includes a forsaking of truth of utterance, and who teach that the vagaries of a mind which has thrown off its responsibility are a mark of its imaginative force.

Nor is it fair to leave him to discover for himself when and where he may, that power is only good after it is assimilated and has become appreciation.

It is not fair to send a student forth into the world, where his first commission may be the painting of a decorative panel, so uninstructed that he does not yet know the first law of decoration, that the ornament shall enrich but not destroy the architectural character and stability of the wall. Had the student even heard of such a law, how could he, all at once, develop the sense of decoration, the appreciation of the character of style? So he must paint a panel like most of those in our public buildings, neither decorative in method, nor justly associated with the architecture, and add another failure to the long list.

Had he been trained in the purpose and range of possibility in his own art, and had he been shown the power that lies in the other arts of design, had he been taught the methods, the standards and the limitations of each, it would have opened his eyes to beauty, enriched his understanding, refined his pleasures and ennobled his craftsmanship. All this has been lost to him because those to whom he committed himself have forgotten that the mind needs food as well as the eye, and that not only discipline but culture go to the making of the artist.

And this is the sorest waste of all; that thousands think they are studying art who are only learning to paint, and that of the few who learn to paint well so few can pass unaided from the standards and aims of the school to the aims and standards of art.

THE APPARATUS OF LOCOMOTION IN *SURIRELLA.*

BY T. CHALKLEY PALMER.

In a recent article in these PROCEEDINGS the views of R. Lauterborn on mechanism of motion in diatoms were discussed to some extent, and were not found quite satisfactory. Notwithstanding the beautiful and sometimes profound studies of this able investigator — studies that should lend a certain weight to his opinions — his conception of propulsion by means of out-flowing coleoderm-substance (*Gallerte*) leaves the patient student of the moving diatom quite dissatisfied. The actual observer cannot reconcile this theory with numerous characteristics of diatom motion. Neither is the matter improved by the learned author's endeavor to correllate the motion of these organisms with that of *Closterium* and *Oscillaria.* As to these and their motions, indeed, while it would not be strictly correct to say that everything has been cleared up, certainly a good deal of water has run under the bridge since 1896. But that is distinctly another chapter, and there is no need to do more than refer to it here.

My present object is to record some notes on renewed studies of the moving diatom, mostly made since the writing of the article referred to; studies that enable me to reënforce the argument from the nature of the phenomena, as I have already presented it, with a few cold facts. These facts would seem to negative Lauterborn's whole argument so far as concerns *Surirella.*

But first the Lauterborn argument must be re-stated with a little more precision. For the sake of clearness, a copy of the essential parts of his figure* of the keel and ribs of *Surirella* is on the next page shown as faithful to the original as an unskilled hand could make it. The author explains that tongue-like processes of the protoplasm (Figure I, P), each enclosing smaller processes of the chromatophors (chrom), stretch up through the rib-canals (R). He states that the honeycomb or webby structure typical of protoplasm is strongly marked in life in these extensions, but that such structure apparently stops short at the keel (K); that within the hollow, tube-like keel it is scarcely possible to see anything; that this keel is full of an apparently hyaline substance, in sharpest contrast to to the contents of the ribs. In order to see this substance directly, it is necessary to practice very strong staining, and thionin and methyl violet were used. Under this treatment there came into view a granular, contracted filament (*ein körniger kontrahierter Strang*) which was usually torn loose from the fibrous plasma strands of the rib-canals. The absolute unlikeness in life, and afterwards the great resistance of the contents of the keel to stains that are well taken by protoplasm, seem to Lauterborn to indicate that

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* Bau, Kernteilung und Bewegung der Diatomeen. Tafel I, Fig. 9. This author studied Surirella calcarata. I have lettered the copy of the figure in a different way from its original.

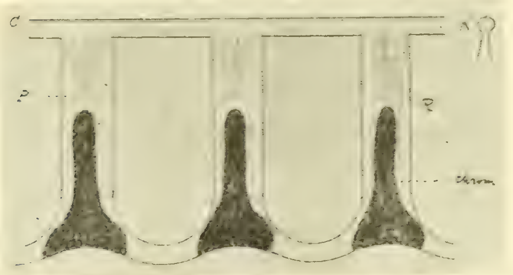

FIGURE I. (After Lauterborn).

the keel-canal is full of an altogether hyaline and freely-flowing jelly-like substance (*einer durchaus hyalinen sehr flüssigkeitsreichen gallertartigen Substanz*) which performs the shifting of extraneous particles along the keel. Now this shifting of particles along the keel is one of the concomitants of the locomotion of *Surirella*, and admittedly due to the operation of the same force that moves the diatom as a whole. The diatom therefore moves, not by the direct action of protoplasm upon the surroundings, but by the action of a secreted jelly (*Gallerte*) circulating in the keel and moving back and forth in the keel-cleft (See Figure I, at the right). There is no protoplasm in this keel — such is the contention.

It would be easy to demand details, and difficult to furnish them, concerning the question as to what causes this "*gallertartigen Substanz*" thus to flow back and forth, and really to function in essential respects like common living protoplasm. But it is to be remembered that Lauterborn, at the time when this was written, was in the midst of a lively controversy concerning protoplasmic limits; and having somewhat rashly denied the existence of plasma currents even *within* the raphe of *Pinnularia*, he had betaken himself to *Surirella* in the search for an argument *a fortiori*. In place, therefore, of further objections on general lines, let us proceed to some definite observations of fact.

In my immediate neighborhood a small spring of exceptionally pure water issues into a basin about three feet across and eighteen inches deep. The pool is well shaded. On the bottom are dark olive patches of diatoms, forming tenacious sheets capable of being lifted nearly free from subjacent sand and loam. These growths consist mainly of millions of *Navicula Iridis* Ehr. and its varieties, but with them live continuously a few *N. Dactylus* Ehr., *N. socialis* Palmer, and *Surirella elegans* Ehr., the last often heavily fringed with *Fragilaria parasitica* Green. The water is so pure and free from toxin-forming organisms that a thick layer of the diatoms keeps in good condition in a bottle of it for weeks at a time. With this material, renewed when necessary, the available time of some months past has been spent in following the living and moving cells, and in attempts to demonstrate structure and mechanism. A number of significant observations were made upon the others, but the apparently conclusive facts uncovered have to do with *Surirella*.

One may observe as best he can, for hours together, this large and beautiful diatom performing its rather fantastic evolutions under a water-immersion objective without a coverglass, or under an oil-immersion and a coverglass, or in any other way he pleases, without once seeing a sign of motion or structure within the keel (K, Figure I), except only that the fibrous protoplasm of the rib-canals may now and then seem to extend some little way into the keel. It all seems very mysterious, the more so since extraneous particles keep travelling intermittently back and forth along the cleft of the keel. Meantime the diatom is awhile upon its valve, after which it rolls gradually over to reveal its girdle, and then slowly elevates itself upon one end. All this time, it may be believed, some focussing is required, both of the eye and of the microscope. After a long course of this the question still remains — how to see the living protoplasm performing these its functions? For in despite of anything that has been said by anyone, the feeling grows with the study, until it becomes a kind of firm conviction, that all the varied little happenings of the *Surirella's* motion are but so many characteristic operations of that familiar, but forever mysterious substance, the protoplasm, in direct action upon the surroundings through the keel-cleft. But if the protoplasm is in the cleft, it certainly is in the tube of the keel. Still — how to see it?

Here it is necessary to state that I find a difficulty in understanding how Lauterborn could see anywhere in *Surirella* a webby structure of the protoplasm on the scale depicted in Figure I. He calls it very obviously coarsely fibrous-honeycomb structure (*grob fibrillärwabig*). Bütschli himself has also mentioned these rib-strands as offering a clear illustration of his foam-structure visible in the living plasma.* It is difficult enough, with a good 1.9 m.m. objective of 1.3 N. A., and with the necessary and correct achromatic illumination, what with all the corrugations of the shining silica scattering rays of light, and the continued motion of the diatom into ever-varying levels, to see even so much as I have sought to depict in Figure II. These strands seem more or less fibrous indeed, as if under some stress, and are of a notably granular structure. They often appear to stretch slightly into the keel, though it is impossible to define their limits in the living condition. However, the chromatophor extensions, instead of confining themselves to the lower half of the ribs, frequently extend to the keel. Now it is a well-understood fact that the chromatophors lie within the protoplasm, which surrounds them on all sides. When, therefore, these tongue-like projections reach the keel, the protoplasm must necessarily extend still farther in the same direction.

It causes me no pangs to confess my inability to see this living protoplasm there, for the inference is plain that protoplasm may exist invisibly in the keel, whether because it becomes hyaline in that position, like a fresh pseudopodium of a rhizopod, or because the curved silicious tube of the keel sadly interferes with the microscopical definition.

However this may be, all signs of structure or motion within the keel were long and most carefully sought in vain.

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*I trust I shall not be understood as entering here—Gott bewahre!—into a discussion of the Bütschli foam-structure of protoplasm. But certainly, in this case cited, I could not see the structure with adequate and correct illumination. On abandoning the achromatic condenser (so necessary in the opinion of the best informed experts of the microscope for the formation of true images with high powers and apertures) and using bright diffused daylight with the mirror only, I could indeed see certain strong lines remotely resembling the reticulations in Figure I. Curiously enough, they were nearly in the indicated place. However, since these lines were demonstrably diffraction images, and since under the conditions all real microscopical definition of the protoplasm structure in the rib-strands was blotted out, I did not find the arrangement useful.

But at length a ray of light came with a search for the "Bütschli granules." This is not the place for a discussion of the nature of these bodies. It must suffice that we recall the fact that they are small granules moving about upon the surface of protoplasm in living cells. Their motions are apparently independent, and two of them may approach each other upon the thinnest strand of quiescent protoplasm. Very conspicuous bodies of this order occur plentifully in the central sap-cavity of *Surirella*, and other smaller granules, with similar motions, are to be seen sparingly on the outer surface of the protoplasm, in contracted spaces between it and the silicious membrane. Lauterborn states that he vainly sought for such granules in the rib-canals, where indeed there is quite enough space for them. I have been more fortunate.

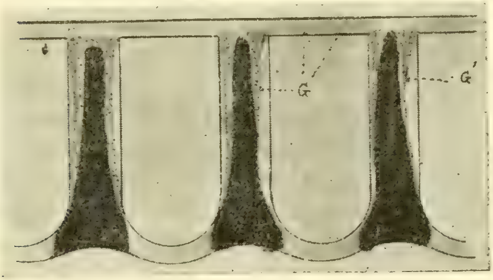

FIGURE II. (Adapted from Lauterborn).

In Figure II, one of these granules is indicated at G′ and another at G. Such a granule was first observed to run gradually, and in a halting manner, nearly to the keel. It then returned and disappeared toward the body of the valve.

Several such occurrences rewarded long observation, and with attention to the matter one of them was distinctly seen to enter the keel at a place where the plasma-strand of the rib-canal did not (as it very often does) choke the entrance. This granule travelled along the base of the keel-canal, and was lost to sight at the next rib. It probably passed behind the protoplasmic strand. Two others, as at G, Figure II, were seen to meet each other midway between two ribs, to remain nearly still for a time, and then to part company. Numerous similar instances were seen, but never without a most intensely concentrated attention (for it is impossible to depict in a figure the delicacy of appearance of these granules) and it could no longer be doubted that such bodies do frequently enter the keel and travel along it. Whether they always confine themselves to the base of the keel is another question, and one not easily answered. I saw none elsewhere in life, but the difficulties of microscopical definition at other parts of the keel are greater. Their essential likeness to the "Bütschli granules" was made all the more evident from the lack of relation between their motions and the simultaneous movements of foreign particles along the outside of the keel-cleft.

Now the large significance attaching to the presence and motion of these granules within both keel- and rib-canals arises precisely from the fact that they are not known to move in this manner except only upon protoplasmic surfaces bathed in cell-sap. This is insisted upon by Bütschli, and their motion is by him attributed to their supposed property of causing a change in surface tension at the contact layer between sap and plasma. We are quite warranted, therefore, in drawing the conclusion that it is upon a protoplasmic strand within the keel that the granules in the keel move, and that this strand, let it be ever so hyaline to all appearance, is in unbroken continuity with the obvious protoplasm of the ribs. There is the further inference, that a layer of sap, or its equivalent, bathes the part of this keel-protoplasm next the ribs. Just what space may here be occupied by the sap it would be difficult to determine, though I would record that granules observed here had a perceptible size. No reason appears, from the structure of the keel-canal, why the whole strand should not be bathed in a fluid, except only the actual thin film which may be supposed to fill the exceedingly narrow keel-cleft to repletion, and seal it against any leakage into the surrounding water. Here comes into play, no doubt, the centrifugal pressure of the diatom — a pressure indicated to be very great by some perfectly legitimate experiments and calculations of O. Müller.

As concerns demonstration of obscure points in diatom structure with stains, I have already had some little experience, and would especially mention again that a mixture of Bismarck brown and tannic acid had years ago been useful in making visible the coleoderm on *Eunotia* and distinguishing it from immediately adjacent protoplasm. This stain was applied to the living diatom. At the same time, sundry examples of *Surirella* underwent the same treatment, and I was altogether unable to see in them any indication of a brown-staining jelly within the keel. On the other hand, eosin subsequently applied gave good stainings of the general protoplasmic mass of *Surirella*, but failed to develop anything of import as to the connection between it and the keel-contents. There was indeed much shrinking of the rib-canal protoplasm, extending often to a complete retirement into the body of the frustule.* It was evident enough that for *Surirella* previous fixing of the protoplasm was a requirement for successful staining. So now, having a desire to develop into unquestionable visibility the keel-contents, I made only small experiments — which led to very little — with stains applied in this manner, but proceeded to fix the diatoms in corrosive sublimate. Into a boiling saturated watery solution of this salt, contained in a test-tube, a quantity of the fresh diatoms was dropped as quickly as possible from a pipette. The fixing was continued only a few minutes, and the diatoms were then washed free of the chemical upon a filter kept constantly full of water. The thoroughly washed filter and its contents were now covered with water in a large watch-glass, and the diatoms properly stained. Several processes of staining were tried, but the best results, so far as concerns *Surirella*, were obtained firstly with aqueous eosin, and secondly with iron-alum and hæmatoxylin. Those stained with eosin were mounted in 2 per cent. formalin cells, and the iron-alum-hæmatoxylin stainings were, with the greatest care, dehydrated with alcohol and put through oil of cloves into balsam. This dehydration and final transfer required nearly a week of waiting. The balsam mounts showed very heavy stainings in the body of the cell, and precisely the right amount of color in the ribs and keels of *Surirella*. Moreover, the process of fixing had been exceedingly satisfactory as regards avoidance of excessive shrinking of the protoplasm. In Figure III I give a sketch of the aspect of affairs in the keel

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*Lauterborn speaks of thionin and methyl violet, and mentions that his preparations showed the contracted strand "in the keel torn loose from the plasma."

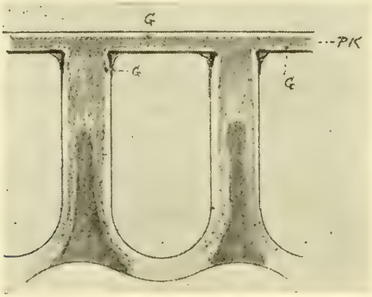

FIGURE III.

of *Surirella* and in the ribs as far as clear vision of details could be had.

The protoplasm of the ribs is stained a dark indigo, and seems made up of a mass of excessively minute particles, interspersed with larger granules. The protoplasm within the keel (PK), after staining, is quite similar, and absolutely continuous with the former. Occasional still larger granules, possibly the Bütschli granules, occur in ribs and keel, and not alone along the base of the latter. The keel protoplasm is surprisingly granular, considering its invisibility in life. It occupies as a rule only about two-thirds the diameter of the keel-canal, and is therefore somewhat shrunken. This also has happened to the protoplasm of the ribs, as is shown at the slightly contracted opening between keel and rib, where the strand, though shrunken, still shows the effect of its constriction in the living state.

While the iron-alum-hæmatoxylin preparations were the most satisfactory, the eosin stainings also were quite conclusive, and indeed in some cases rather preferable on account of less shrinking of the protoplasm. In places this still almost fills the keel-canal and remains in contact with the constricted openings of the ribs. Since both stainings are from material fixed at the same time, it is probable that the iron-alum operation had some slight shrinking action of itself, though the dehydration may also have contributed.

To sum up the facts as to the protoplasmic nature of the keel-contents of *Surirella* :—

1. Bütschli granules, or bodies of the same deportment in life, circulate into the keel and run along its base.

2. Staining the living diatom with Bismarck brown and tannic acid fails to indicate coleoderm within the keel, though revealing it in the same preparation upon *Eunotia* and *Pinnularia*.

3. After rapid killing and fixing, both eosin and iron-

alum-hæmatoxylin show the keel-canal more or less full of a substance continuous with the protoplasm of the rib-canals, and staining like it, and showing the same granular constitution.*

I consider it demonstrated, therefore, that the protoplasm of *Surirella* extends through the ribs into the keels, wherein it runs from end to end of the diatom and occupies most of the tube-like canals. Altogether it is quite evident that this hyaline protoplasm, and not any hypothetical "*Gallerte*" flows back and forth in these keels, and operating upon the surroundings through the minute clefts (where indeed there may be a slight film of gelatinous substance) propels the diatom, rolls it over, and stands it upon its end. This is a kind of apparatus for diatom locomotion easily understood; and besides being in comfortable agreement with the nature and peculiarities of the phenomenon to be explained, it has the not inconsiderable advantage of being demonstrable.

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*The marked contrast between this keel-canal protoplasm and typical "Gallerte," so far as concerns granular structure, was well shown in the stained preparations, where the coleoderm of Navicula Iridis showed more like a jelly containing only the most minute granules, all nearly of one size; — in short, what might be expected of a structureless secretion.

NOTES ON NAUTICAL LANGUAGE.

BY HENRY L. BROOMALL.

The technical nomenclature of an art differs from that of a science because art precedes science in human development. As an art develops, it adapts its language to its necessities and changes without reference to the causes and principles that underlie particular acts. Science, on the other hand, involves retrospect, comparison and meditation, and these processes produce a nomenclature expressing relationship and classification ; it is an after-thought.

The technical language of an art, therefore, has particular interest and value for linguistic and anthropological studies because it directly represents the steps of human progress in the making. It has more vitality. As an expression of humanity, it is less artificial. And of this, the language of the sailor is an apt illustration because the pursuit of his art segregates him and his fellows from his original community and gives full play to linguistic peculiarities.

Navigation is an old art among the English people. From the time of the adventurous forays of the so-called Northmen, of which the settlement of England by our Teutonic ancestors was a result, the sailor and his art have constituted the elements from which has grown the English commercial empire of to-day. The sailor's language preserves words and forms of speech that are now changed or lost in standard English. This is illustrated by his active use of the prefix *a*, equivalent to *on*, as in *aboard*, *abeam*, *astern*, *amidships*, *aweather*, *atrip*. He puts the helm *hard alee* or *aport* or *astarboard*. A sort of adverbial use of *to* is delightfully easy and expressive ; the ship *heaves to*, *brings to* or *comes to ;* a coast is *steep-to* with no soundings *close-to ;* or the ship has a *lean-to* to windward.

Upon heaving the lead the sailor reports the result as "and a quarter five," which means five fathoms and a quarter, or, "a quarter less five," which means four fathoms and three-quarters. This reminds us of Latin *sestertius* for *semistertius*, or German *halb vier*. Another old form is well preserved in the naming of those intermediate points of the compass called the "by" points. *North by east*, for example, is the first point east of north. This is simply the modern version of Anglo-Saxon *be-eastan*, to or on the east of, *her-be-eastan*, east of here. Were the idea only modern, the phrase would be *east of north*. The student of Early English will recognize in these specimens the ring of the old tongue.

Aft and *abaft* are now used only by the sailor. To the landsman *aft*, *abaft* and *after* have no particularly distinctive and relative value. On shipboard, however, these words are neatly distinguished in grammatical use, *aft* as adverb, *abaft* as preposition, and *after* as adjective. Thus the sailor would say, "He walked aft: he stood abaft the wheel: he watched the after-sails."

While the sailor's language, almost as a dialect, thus preserves old forms, yet its progressiveness from generation to generation gives free play to the operation of phonetic changes. The old variants *strop* for *strap* and *strake* for *streak*, used by sailors, as well as *bilge* for *bulge* and *taut* for *tight*, show both the relation and the distinction between the technical language and the standard language. The free play of phonetic change is illustrated in *channels* for *chainwales*, *gunnel* for *gunwale*, *rullock* for *rowlock*, and *trunnel* for *tree-nail*. The same thing appears in the pronunciation of *studding-sail* as *stuns'l*, *forecastle* as *fōc's'l*, *bowline* as *bō-lin*, *leeward* as *loo'rd*, *forward* as *fŏr-d*, *topsail* as *tau-s'l* and *boatswain* as *bō-s'n*. But we can hardly expect that the dictionary will soon acknowledge *flu'es* for *flukes*, *davies* for *davits*, *bully-beef* for *bouilli-beef* or *dilly-wreck* for *derelict*. Yet pronunciations such as these are facts in nautical parlance. Whose authority is higher than the sailor to whom these words belong?

The English sailor has adopted many words from foreign tongues with which his voyages have brought him in contact.

These foreign words have either not been introduced into standard English or else, if introduced, they appear in a different form. The latter proposition may be illustrated by the sailor's word *lateen*. It is the name of a sail spread upon a long yard slung at an oblique angle to the mast, a rig originally peculiar to the Mediterranean. When the English sailor added this kind of sail to his knowledge he naturally gave it the name of the people from whom he acquired it — the Latin — by which was meant the people we now differentiate as Italians, Spanish and French. *Lateen*, therefore, is the nautical form of the word *Latin*, its accent and spelling showing that it was adopted by ear. It retains its accent on the last syllable because it has not had sufficient general use in English to subject it to the tendency toward accent on the first syllable which has produced the standard *Lat'in* from *Lati'nus* and *Lati'no*. So the Dutch *jol* and Danish *jolle*, where *j* is equivalent to English *y* in sound, become the sailor's *yawl*, while the written word, converted to our sound of the letter *j*, produces the word *jolly-boat*, in which *jolly* has acquired an English significance as descriptive of the light, easy character of the little craft, and the word *boat* has been added to complete the sense to English ears.

Sometimes the nautical and standard forms differ because of diverse origin. *Cargo* for example, is a Spanish and Portuguese form of *charge*. The latter comes to us through the French, as an item of our Anglo-Norman vocabulary, while *cargo* and such words as *stevedore*, *compass*, *binnacle*, *mizzen*, are foreign terms introduced from the Italian, Spanish and Portuguese peoples who preceded the English in commerce and navigation. *Binnacle* and *compass* represent the use of the needle adopted by the northern from the southern sailor. *Mizzen*,* like *lateen*, names a particular kind of sail used in Southern Europe. *Cargo* and *stevedore* represent the commercial side of navigation cultivated in the South while the Northerner was still a pirate or a freebooter.

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*See PROC. DEL. CO. INST. SCI., Vol. II, p. 29.

This supremacy of the South Europeans in commerce, by which the products of the newly discovered countries of the fifteenth, sixteenth and seventeenth centuries were first brought to Europe, taught us the names of these products in Italian, Spanish or Portuguese form. Thus, *indigo* has this distinctive form because the product was so named by the South Europeans when they introduced it. It is simply their form of the Latin word *Indicus*, whence by other lines of adoption we have our word *Indic*. It was an Indic or Indian product. The *banana*, *potato* and *tomato* are stamped as foreign by the final *a* or *o*, and they are simply Romance forms of names given the products by the natives of the countries whence these products came or were thought to come.

The main part of our nautical vocabulary, however, is Teutonic. Most of it is Old English. Much of it is Scandinavian and Dutch. *Sloop* and *schooner*, for instance, are probably Dutch, and yet they may be our own words influenced by the similar Dutch words. The nautical supremacy of the Dutch, succeeding the Spanish-Portuguese and preceding the English, naturally brought the sailors of the Netherlands and of England into such intimate relations, hostile or friendly, as to cause interchange or amalgamation of technical words.

On shipboard the points of direction are fore and aft, starboard and port. Things that are constant and on the ship itself generally retain these names. Beyond the ship itself *fore* becomes *ahead*, as "a buoy dead ahead," and *aft* becomes *astern*, as "a light astern," which means a light seen off the stern of the speaker's vessel. Many things that are *starboard* and *port* when at anchor become *windward* and *leeward* when under sail. The direction of the wind then becomes paramount in the mind of the sailor. If at anchor, the sailor is told to move a thing "to starboard," toward the right side of the ship, or "to look out to starboard," for another vessel, but, if under sail, he is told to move it or to look "to windward" or "to leeward" as the case may be, that is to say, to the direction from which or to which the wind blows. But the starboard and port watches, composed of certain divisions of the crew, alternately on deck, do not change name to suit the wind. The master's post on the starboard of the poop or quarter-deck when at anchor immediately becomes the windward side when under sail, changing with every new tack. A sailor, coming aft to take his trick at the wheel, always comes to the poop or quarter-deck by the leeward side when under sail. Otherwise, he would come by the port side. So, the green and red lights are always known as the *starboard* and *port* lights, while the sheets trimming the sails to their proper angle are called *windward* or *leeward* as it may happen. But if the ship were at anchor, even these sheets would be described as starboard or port.

In all ages the prow of a vessel has been likened in shape and name to the head of an animal or some feature of that part of the body. The old Romans applied the word *rostrum* to the stem of a vessel just as we use our word *beak*, the French *bec*, the Germans *Schnabel*, and the Spanish *rostro*. Italian *sprone* and Spanish *espolon*, cock's spur, are used in the same way. The commoner term among English and French sailors, however, is *head*, French *cap*, from Latin *caput;* whence our synonymous verbs *to head* and *to cape*. The French sailor says, "*Où est le cap?*" just as the English says, "How does she head?" Sailors colloquially speak of the vessel's stem or prow as "her nose," from its projection, or as "the eyes of her," partly from the eye-like position and shape of the hawse-holes; they describe a wind dead ahead as "right in her teeth"; a timber at the foremost end of the keel at the stem is known as the "apron" or "stomach-piece," which the Frenchman calls *gorgère*, or neck-cloth, from *gorge*, throat; Spaniards call the bulging sides of the vessel at the bow *los cachetes*, and the French *les joues*, the cheeks.

We find these terms transferred to the vessel itself. From "her eyes" we have the *bug-eye* or *buck-eye* of the Chesapeake. German *Schnau*, from the same root as snout, is applied to the vessel called in English a *snow*. Probably *smack*, whence French *semaque*, is, by the easy change of *n* to *m*, from Old English *snaec*. The same word appears in Old English *naca*, with which compare French *nacelle*. From this root, too, comes the modern *sneak-boat*, the word *boat* having been added when the meaning of the first part was forgotten, and the compound is now generally considered as referring to the sneaking movement of the boat. Old Flemish *snebbe*, equivalent to German *Schnabel*, was applied to the beak of a vessel and also to a vessel described as "barque longuete." These instances of naming a vessel by synecdoche from the prow give some support to Wedgewood's suggestion that *navy*, Latin *navis*, Greek *ναῦς*, may be from the same root as *nose*, and that our words *bark* and *barge* and their European cognates may be from Old Norse *barki*, throat.*

The comparison to the animal form is extended to other parts of the vessel, as in German *Bauch*, belly, English *bilge*, the part that *bulges*, the belly of the ship; the *waist*, the midship portion; the *back*, the keel and kelson; *broken-backed*, to be *hogged*, or, as the Germans say, *einem Katzenrücken aufgestochen haben*, to be strained so as to bend the hull like a hog or cat's back; the *ribs*, Spanish *costillage*, French *côtes*, timbers which spring from the keel as ribs from the backbone; *quarters*, equivalent to the hind-quarters of an animal, called by French sailors *hanches*, hips; and *buttocks*, German *Hinterbacken*, French *cul* and *fesses* and their English monosyllablic equivalent, applied to the afterpart or stern of the vessel. From a particular resemblance to the animal the many-oared vessels of former times were facetiously called *hedgehogs*, just as later an iron-clad was known as *hog-in-armor*. Another likeness in shape gives the lately introduced

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*See "Colloquial Ship Names," PROC. DEL. CO. INST. SCI., Vol. III, p. 170.

whaleback — an idea which was expressed earlier in *turtleback*, a deck curving from the sides upward to protect the machinery within, and the phrases "to turn turtle," to capsize, with reference to a vessel's appearance when upset.

But when the name of an animal is applied to a ship, the transfer arises from the lifelike movements of the vessel rather than from the resemblance of form. The use of the feminine pronoun in speaking of a vessel may be considered as a general expression of the lively, graceful action of a vessel under sail, though the appellative nouns are not without some freaks in the matter of gender. The apparent inconsistency of gender in *man-of-war*, *merchantman*, *fisherman* and the like, can be explained satisfactorily by the fact that all such names refer more particularly to the actions or business of the ship's crew than to the usual, graceful — and therefore feminine — movement of the vessel herself. This also accounts for the use of *we* and *he* for our own and the enemy's vessel in conflict, where the hostile animus is so strong that the vessels' personalities are completely overborne by those of the combatants. In describing the "behavior" of a vessel, her action under sail and so on, no matter what her professional name may be, the pronouns applied to her are always feminine because her motions are graceful. But the gender is changed in those compounds where the unsophisticated mind is confronted with the absurdity of considering a vessel in the act of war, piracy or business — pursuits pretty much alike at bottom — as other than masculine.

Homer's metaphor, ἁλός ἵπποι, is paralleled by modern instances. Arabian *baggala*, mule, is applied to a two-masted vessel of the Indian Ocean, doubtless in reference to it as a ship of burden. *Monkey-boat* and *cat-boat*, German *Katzschiff*, French *chat* and *chatte*, names of small boats, seem to refer to quick, light movement. *Lighthorseman*, a former name for the boat we now call the gig, alludes to speed, a characteristic still more plainly referred to in the term *greyhound*, which it is said was first applied to the Atlantic Liner "Alaska" in

1882, when she broke the record by making the trip across in less than seven days. This recalls *yacht*, ultimately from Dutch *jaghen*, to chase, hunt. *Ram*, like Latin *aries*, English *battering-ram*, refers to the characteristic action of the animal. In contrast with these active vessels, those without sails or steam-power, as lighters, punts and canal-boats, are described by the sailor as *dumb-craft*.

The foregoing examples, illustrating the vitality of the sailor's language in grammar, phonetics, vocabulary and metaphor, suggest that his peculiar speech is not only a technical nomenclature, but an active collateral growth from the standard historic tongue. It reminds us of colonial dialects where old words and grammatical forms are preserved more tenaciously than in the mother countries. Colonists and sailors are not usually derived from the "successful" and cultured classes. They are rather the energetic and insubordinate, who are better fitted to win in the material conflict with natural elements and conditions than to succeed in the intellectual, nervous, complex conflict with their civilized fellow-men. Under colonial and nautical conditions alike, purely intellectual progress, with its accompanying change in the use and meaning of words, is almost wholly checked, and the adoption of new words with new things represents the only linguistic advance. Hence it is that our nautical language preserves old forms of speech and yet easily adopts new words suited to its needs as the sailor comes in contact with the foreigner and his new products.

LONGEVITY.

The library of the Institute of Science contains many rare and old books. Among these are a few odd copies of "Poor Richard's Almanack." In one of these for the year 1751 there is a note concerning long lived persons which may be of interest. The note refers to an event which happened 40 years before the publication of the "Almanack," and for many reasons it is probable the figures are incorrect. It is interesting, however, to know what the people of those times believed they could do in the matter of long life: —

On the 6th of this month (December), 1711, died in England, Mrs. Jane Schrimshaw, aged 127 years. But England boasts some much longer livers. James Sands, of Horburn, in the County of Stafford, near Birmingham, lived 140 years, and his wife 120, in a perfect state of health till the day of their deaths. He outlived five leases of 21 years each, all made after his marriage. Thomas Parr, married his first wife at 80 years of age, by whom he had two children; his second wife after he was 120 years old, by whom he had one child, and lived till he was something above 150. Henry Jenkins, of the Parish of Bolton, in Yorkshire, died the 8th of this same month, 1670, aged 169 years. In these American parts we have no such very old men; not that the climate is unhealthy, but because the present inhabitants were not born soon enough.

MINUTES OF THE INSTITUTE.

MAY 5, 1910. — Annual meeting of the Institute. In the absence of the president and vice president, Albert S. Barker was made president pro tem. Routine business and annual reports of officers and committees. Albert J. Williams, of Media, was elected to membership. The annual election of officers was held, with the following result: —

President, T. Chalkley Palmer
First Vice President, Henry L. Broomall
Second Vice President, Charles Potts
Secretary, B. M. Underhill
Treasurer, C. M. Broomall
Librarian, Henrietta K. Broomall
Board of Curators, Edgar T. Miller and Homer E. Hoopes

The following acquisitions to the library were announced: "Twenty Years in Congress," by James G. Blaine; "History of Pennsylvania Volunteers," Volumes III, IV and V. Following the business meeting a lengthy discussion was had concerning comets and other astronomical phenomena. Albert S. Barker exhibited a novel form of polariscope, consisting of two mirrors of black glass so arranged that the light polarized by reflection from the first mirror is received upon the second mirror at the polarizing angle and in the plane of extinction; and provided with a stage placed between the mirrors for the support of the films of mica or selenite, crystallizations, etc. In this apparatus chromatic effects are produced such as are obtained in the ordinary polariscope, when polarizer and analyzer are crossed. Mr. Barker also gave a demonstration of the real image formed when rays from an object are received upon a concave mirror and converged by reflection to a focal plane in front of the mirror. After further discussion the meeting adjourned.

JUNE 2, 1910. — Regular monthly meeting, with President T. Chalkley Palmer in the chair. Reports of committees and officers. Mrs. Julia W. Barker, of Media, was elected to membership. The following donations to the library were announced: "A New Radiation Pyrometer," by C. B. Thwing; "African Characinid Fishes," by C. A. Cocherell. Under scientific business Henry L. Broomall gave a talk upon the changes of English vowel sounds, illustrating the subject by diagrams, examples, etc. After general discussion the meeting adjourned.

JULY 7, 1910.—Regular monthly meeting, President T. Chalkley Palmer in the chair. Reports of curators, committees, etc. Donations to the library were announced as follows: "Description of a New Sub-species of an African Monkey," "Recalculation of Atomic Weights," "Mechanics of the Earth's Atmosphere." Under the head of scientific business President T. Chalkley Palmer described the sounds made by some turkeys observed by him which indicated almost a language. It appeared that one sound emitted by the old bird sent the obedient young ones to cover in a hurry and that subsequently an entirely different sound brought them into the open again, when the danger had passed. The balance of the evening was occupied by Henry L. Broomall in a lengthy talk on the laws of phonetic changes of words in passing from one language to another. Adjourned.

MINUTES OF SECTION A.

MAY 12, 1910. — T. Chalkley Palmer exhibited *Neidium iridis* Ehr., latterly classified in *Navicula*, finally placed by Cleve in *Neidium* under another specific name. A talk upon this specimen was illustrated by blackboard drawings. Mr. Palmer also showed *Surirella* bearing a number of *Fragilaria parasitica*, and sporangeal frustules on *Navicula amphigamphus*. A. S. Barker exhibited an ophiurian from Florida, a sand dollar or sand star (with the preceding included in the Order Echinodermata), sand from sponges, *Gorgonia* (related to the sea fan), and various species of sponges and corals.

MAY 19, 1910.—With this session began a series of meetings devoted to the consideration of stated subjects. Subject for this evening, "Starfish," led by Dr. B. M. Underhill.

MAY 26, 1910. — Subject, "Mechanics of Planetary Motion," led by C. M. Broomall.

JUNE 9, 1910.—Subject, "Protozoa," led by A. S. Barker.

JUNE 16, 1910.—Subject, "Magic Sqares," illustrative of mathematical peculiarities, led by Prof. Alpheus Moon.

JUNE 23, 1910. — Subject, "Animal Classification," led by Dr. B. M. Underhill.

JUNE 30, 1910.—Subject, "Fundamentals of Refraction," led by Albert S. Barker.

JULY 14, 1910. — Subject, "Unicellular Life," led by C. Edgar Ogden.

JULY 21, 1910. — Subject, "Midsummer Botany," led by Sanford Omensetter.

JULY 28, 1910. — Subject, "Historical Geology," led by Dr. B. M. Underhill.

INSTITUTE NOTES.

Benjamin T. Levis, of Media, has recently presented to the Institute a bound volume of the *Delaware County Republican* covering the years 1835 to 1839. About this time the Institute was in its infancy, and at intervals throughout this period appear advertisements in the *Republican* of the monthly meetings at various points. It seems to have been the custom for the meetings to be held at the houses of different members. It is supposed that the society took possession of its first permanent headquarters near the Rose Tree about the year 1836. The first of these advertisements reads as follows: —

> A stated meeting of the Delaware County Institute of Science will be held at the home of Isaac Hall, in Providence, on the second day of May next, at 2 o'clock P. M., at which time officers for the ensuing year will be elected.
>
> M. PAINTER, Secretary.
>
> April 24, 1835.

During the past three years the activity of Section A has been remarkable. The attendance has been good, and there has been no flagging of interest in any way. The sentiment among the membership has radically changed in the matter of the best method of carrying out the scientific work of the Institute. The work of Section A has shown without question that much better results are obtained by this method of work than by formal lectures. As a consequence the lecture course of the Institute has dwindled down from three lectures a month to one.

Arrangements have been made in the laboratory of the Institute for a series of bacteria counts of the Media water supply, to extend over a period of a year or more. About five years ago a series of chemical analyses, covering about the same period, was made, the results being published in Volume I, Number 1 of the PROCEEDINGS.

The activity of the biological students of the Institute has led to the purchase recently of a number of standard works on biology and biological chemistry. Among these are: "Text Book of Zoology," Weysse; "Protozoology," Calkins, and "The Microscope," Carpenter.

C. Edgar Ogden has recently presented to the museum of the Institute a number of fine specimens of minerals collected during a recent visit to Florida and the South. The mineral collection of the Institute is quite large, and donations of this class are very welcome.

Dr. B. M. Underhill has presented to the museum of the Institute a dissected crayfish, nicely mounted on cardboard, with the various parts numbered and named. The crayfish is a type form for biological study, and the donation is much appreciated.

The present number of the PROCEEDINGS completes Volume V. The cordial welcome which our publication has received from other societies and journals is a source of gratification to the Publication Committee.

The naturalists of the Institute are contemplating several biological and mineralogical excursions to points of interest in this section during the summer.

ERRATA:

Page 146, line 11—For "correllate" read "correlate."
Page 168, line 17—For "Sqares" read "Squares."

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